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AN

INTRODUCTION

TO

ELECTRICITY.

IN SIX SECTIONS.

I. Of Electricity in general.

II. A Description of the Electrical Machine.

III. A Description of the Apparatus (belonging to the Machine) for making Electrical Experiments.

IV. How to know if the Machine be in good Order for performing the Experiments, and how to put it in Order if it be not.

V. How to make the Electrical Experiments, and to preserve Buildings from Damage by Lightning.

VI. Medical Electricity.

THE THIRD EDITION.

Illustrated with Copper-plates.

By JAMES FERGUSON, F.R.S.

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MDCCLXXVIII.

ADVERTISEMENT.

HAving lately added to my Electrical Apparatus, Models of all the Machines repreſented in the ſecond and third plates, which I have reaſon to believe were never made for the like purpoſe before, and having obſerved that the Experiments maae by theſe Models ſeemed to pleaſe thoſe who have ſeen them, I now publiſh an account of them; hoping that others may copy them for their own amuſement and that of their friends.

If any one who is already acquainted with the various operations of Electricity condeſcends to read this ſmall treatiſe, he will ſee that it is written chiefly for thoſe who ſcarce know how to make the common Electrical Experiments, or even know how to keep a Machine in good order for that purpoſe.——And if the following directions, and explanation of the Cauſes why the reſults of the operations are ſuch as we find them, be kindly received by ſuch perſons, my deſign will be fully anſwered.

J. F.

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AN

INTRODUCTION

TO

ELECTRICITY.

SECTION I.

Of Electricity in general.

1. THE term ELECTRICITY is derived from ηλεκτρον, the Greek name for amber, which Theophraſtus, about 300 years before Chriſt's birth, found to attract light bodies, ſuch as chaff and bits of ſtraws; but now it is extended to ſignify the like power in all other bodies wherein that power reſides.

2. All bodies that we know of have more or leſs of the electric matter or fluid in them, which ſeems to lie dormant till it be put in action by rubbing, and then (in a dark room) it appears like fire.

3. Some bodies do freely admit this fluid, or fire, to paſs through their pores, and others do not.——The former of theſe are called *Non-electrics*, or *Conductors*: and of this ſort are all kinds of metals, living creatures, water, and moiſt wood; but metals are found to be the beſt of all conductors. The latter, which do not admit the electric fluid to paſs through their pores, are called *Electrics* or *Non-conductors*: and of this ſort are glaſs, wax, roſin, dry glue, baked wood, and ſilk. But if either of theſe be wetted with water, the water that adheres to it will become a conductor. —— Conſequently, when any body is to be uſed as a non-conductor, it ſhould be well wiped with

 a dry

a dry warm cloth, to clear it of damps, which it may have contracted from the humidity of the air, or from people's breath.

4. The quantity of electric fire which every body has lying dormant in it, is called its natural quantity; and this would always remain motionless and invisible, if nothing disturbed it.——But when any more is forced into it, as, suppose at one end, the whole is instantly put into motion thereby, and begins to be driven out at the other, if it can find a passage *; as if a long narrow tube, open at both ends, be filled with water, and laid down on level ground, the water will remain at rest in the tube; but, if a syringe be filled with water, and fixed to either end of the tube, and then the piston of the syringe be pushed inward, to force more

* In conductors of electric fire, sharp points are as free passages as the open ends of tubes are for water.

water into the tube, the whole water in it is thereby inſtantly put into motion, and begins to run out at the other end.

5. The earth is the grand ſource of electric fire, and no additional quantity can be forced into any body but from the earth. If the body be a free conductor, and has a communication with the earth by means of any other conducting ſubſtance, as metal, or by a table, to the floor and walls of a room, and from thence to the earth, the electric fire will run as faſt from the conductor to the earth, as it is by any means driven into the conductor. But if the communication between the earth and the conducting body be cut off by means of any non-conductor, ſome of the electric fire may be forced into the conductor, by which means it will have more than its natural quantity; and the earth, from which that additional quantity comes, will have ſo much the leſs:

which could never be, if the electric fluid were not of an elastic nature, or could not be compressed.

6. When any body has more than its natural quantity of this fire or fluid, it is said to be electrified positively, or *plus*; and when it has less than its natural quantity, it is said to be electrified negatively, or *minus*.—And the machine may be made so, as to electrify either of these ways.

7. When bodies are electrified either of these ways, they repel each other; but if some be electrified *plus*, and others *minus*, they mutually attract: or, if one body be electrified *plus*, and the other no way at all, they also attract each other.

8. If one body, as suppose a piece of metal, be kept for some time in an electrified state, by means of the machine, and an un-electrified light body, as suppose the down of a feather, be

brought near the metal, the feather will be attracted to the metal, and electrified thereby: on which it will be immediately repelled therefrom, and will not return to the metal again, till after it has touched ſome unelectrified body that is of the conducting kind, and depoſited its fire thereon; and then, if the diſtance be but ſmall, as about two or three inches, it will return to the electrified metal as before, and be repelled from it again.

9. If a fine linen thread be tied to the down of a feather, and allowed to hang downward from it, ſo as almoſt to touch the table or floor, and the feather be brought near the electrified metal, it will be attracted by the metal, and cling thereto, as long as the metal is kept in an electrified ſtate. For then, as faſt as the feather receives the electric fire, that fire will run off by the thread to the table or floor, ſo that the feather can retain no more fire than what

is

is equal to its natural quantity. But, if the thread be cut off close by the feather with a pair of sciſſars, the feather will then be immediately electrified *plus*, and repelled from the metal.

10. If a round piece of metal be electrified, and any pointed piece of metal be held near it, the point will draw off the fire from the electrified metal, if that which has the point be supported by any conducting ſubſtance.

11. If the middle of a wire that is pointed at both ends, be fixed to a ſtick of wax, and either of the points be held near the metal which is kept in an electrified ſtate by the machine, that point will draw off the fire from the metal, and the fire will run off from the other point into the air.——This ſhews that metal points throw off fire as well as they attract it; which is very remarkable. If this experiment be made in a dark room, the electric fire drawn from

the metal will appear like a round ſpark on the point that attracts, and be ſeen going off in the form of a cone from the other point.*

12. If a large globe of metal be electrified poſitively, it will retain the electric fire for ſome conſiderable time. For the ſurrounding air prevents the accumulated fire from iſſuing ſo faſt from the globe as it otherwiſe would. If two globes of metal be hung by ſilk lines, or placed on wax, at about two feet from each other, and one globe be then electrified, and the other be hung or placed near it; the former will ſoon loſe part of the electric virtue, which will be drawn off by the latter; but the point of a needle would draw it off much ſooner.

SEC-

SECTION II.

A Deſcription of the Electrical Machine.

13. THE electrical machine, moſtly now in uſe, and as it is made in the greateſt perfection by Mr. *Edward Nairne,* Optician in Cornhill, London, is repreſented by Fig. 1. of Plate 1. in which *A* is a glaſs globe, *B* the handle or winch that turns it, by means of ſome wheel-work within the braſs box *C*; and *D* is a cuſhion, covered with red baſil leather, for rubbing gently againſt the globe. The cuſhion is ſupported by a braſs ſpring *E,* and may be made to preſs more or leſs againſt the globe, by turning the ſcrew *F* forward or backward; *GH* is the prime conductor, which is a braſs tube with a round hollow ball at each end. The braſs piece *I* is ſtuck into a hole in the ball *G,* and has ſe-

veral

veral ſmall forks of braſs or ſteel, with ſharp points, which almoſt touch the globe. The barrel of the conductor is put into the braſs ſocket *a*, (which may be done after taking off the ball *G)*, and to this ſocket is joined the braſs ſocket *K*, in which the upper end of the glaſs tube *L* is fixed with cement, and the lower end is cemented into the wooden foot *M*.—The glaſs tube, being a non-conductor, inſulates (as it were) the prime conductor *GH*, by cutting off all conducting communication between it and the earth. For, as the electric fire comes from the earth to the machine, and is put into motion and action by the rubbing of the glaſs globe againſt the cuſhion, and this fire goes round with the globe to the points *I*, which attract it and carry it to the prime conductor; if the conductor were not inſulated in this manner, or hung by ſilk lines, the fire would run as faſt from it to the ground, as it received the fire

from

from the globe; and then the whole machine would be good for nothing.

14. Theſe are all the parts of the electrifying machine itſelf;——the reſt to be here deſcribed are only the different parts of the apparatus belonging to it, for making experiments. And note, That when any of theſe are uſed, all the others ſhould be ſet at leaſt one foot from the machine. For, as the electric fire ſpreads about to ſome diſtance in the air, if any conducting ſubſtance be near any perſon or thing that is to be electrified, it will attract and carry off part of the fire, and make the experiment the more tedious and leſs ſucceſſful.——So that, when either the balls *O* and *P* are uſed, or the crooked wire *c d* with the fly *e f g h i k*, or the piece *Q* with the bells *R*, *S*, *T*, or the Plates *X* and *Y*, or the feather *b*, or cotton *m*, it muſt be uſed by itſelf after all the reſt are taken away.——And they are only put to the conductor in this figure, to

ſhew

ſhew how each is to be put thereto by itſelf, when an experiment is to be made with it.

15. The holes in the prime conductor, for receiving the ends of the wires *N, c, d,* and the feather *b,* ſhould be well rounded off, and made ſmooth about their edges. For, if the edges are left ſharp, they will be of the ſame nature as points, in throwing off the electric fire; and this would ſpoil the experiments.——I ſhall next deſcribe the different parts of the apparatus belonging to my electrical machine, of which thoſe in Plate 2. are entirely new; at leaſt they are ſo to me.

SEC-

SECTION III.

A Deſcription of an Apparatus, belonging to the Machine, for making electrical Experiments.

PLATE I. FIG. I.

16. O and *P* are two little balls, made of pith of elder, to which the ends of a fine linen thread (about 7 or 8 inches long) are fixed.——When they are uſed, they are hung by the middle of the thread upon a wire *N*, cloſe by a round ball of metal, which is fixed upon one end of the wire; and the other end is then ſtuck into a hole in the end *G* of the prime conductor *GH*.

17. *cd* is a crooked wire (which muſt be roundiſh, not ſharp at the bended parts) to be ſtuck into a hole in the uppermoſt

uppermoſt ſide of the prime conductor-ball *G*. The top of this wire above *d* muſt be ſharp; and *efghik* is a fly made of ſmall braſs wire; the ends of each arm next the center being fixed into a braſs cap, which is to be put upon the point of the crooked wire; and the other ends of all the arms are bent one way, in an horizontal direction, and terminate in ſharp points. Each bended part *e*, *f*, *g*, *h*, *i*, *k*, muſt make a ſort of a right angle with the reſt of the arm between it and the center, and theſe bendings muſt be roundiſh, not ſharp corners.——When this fly is put upon the top of the crooked wire *cd*, it hangs like a mariner's compaſs upon the pin that ſupports it.

18. *Q* is a braſs hook fixed to a croſs bar of braſs, from which hang three bells *R*, *S*, *T*, with their clappers *U* and *V*, which are ſmall braſs balls.——The bells *R* and *T* are hung by metal chains; the middle bell *S* by a ſilk line, and the clappers

clappers by ſilk threads.——A metal chain *W* hangs from the middle bell, the lower part of this chain lies on the table (to which the electrical machine is fixed) and a piece of ſilk cord *w* is tied to the lower end of the chain.

19. *X* is a thin braſs plate, to be hung to the prime conductor by a metal hook; and *Y* is another of the ſame ſort, but a little larger, to be placed below it. A braſs wire is fixed into the middle of the plate *Y*, and is moveable up or down in a braſs ſocket *Z*, for raiſing or letting down the plate which may be fixed at any proper height by means of the ſcrew *z*: and the loweſt end of the ſocket may either be ſtuck into a hole in the wooden foot *M* of the prime conductor, or have a metal ſtand of its own, which is the moſt uſual way. For, in making experiments with it, no matter under what part of the conductor it be placed, if the other plate be hung directly over it.

20. *b* is a large plumy feather, ſuch as young ladies wear in their caps. That of an oſtrich is the beſt.

21. *m* is a ſmall lock of cotton, part of which muſt be drawn out into a ſhort thread, and thereby fixed with a bit of bees-wax to any part of the undermoſt ſide of the prime conductor, (any where between *Q* and *X* would be better than where it is repreſented) and then, before the experiment with it be made, it ſhould be pulled out by the hands into ſuch a lax ſtate, as that the different parts of it may only hang together by ſmall ſhreds, and the loweſt part of it ſhould be drawn out to a ſhred.

22. In Fig. 6. *ABC* is a bended wire, the end *A* being made blunt, and of ſuch a ſize as to fit either of the round holes in the prime conductor, inſtead of either the ſtraight wire *N*, or the crooked wire *c d*; and the end *c* muſt be a ſharp point.

23. In

23. In Fig. 2. *A* is a glaſs jar, coated on the outſide, and lined on the inſide with tinfoil to about two inches ſhort of its top, which is ſtopt with a thin cork, firſt dipt all over in melted wax. A ſtraight braſs wire is put down through the middle of the cork, quite to the lining which covers the inſide of the bottom of the jar; and a ſmooth ball *a* is fixed on the top of the wire, which muſt be of ſuch a height as to touch the ball of the prime conductor when the jar is ſet near enough to it on the table.——*B* is the diſcharger, which is made of ſtrong braſs wire, bent into the form of part of a circle; and has two braſs balls *c* and *d* fixed on its ends. The braſs balls on the tops of all the wires belonging to the ſeveral jars ought to be of equal height when they are ſet upon a table. The thinner theſe jars are, they are ſo much the better for electrical experiments. The coating and lining are generally fixed to them with thick ſtarch, or book-

binder's paſte; but I find that thick varniſh, ſuch as is uſed by coach-makers, does better for that purpoſe; and dries immediately, which the other does not.

24. In Fig. 3. *A* is juſt ſuch a jar as the one above deſcribed; only it has an additional wire *B*, bent into the form of a ring, ſo as to fit the outſide, and remain on any part of the coating over which it is placed; with a braſs ball *D* on its top, of equal height from the table with the ball *C*.——*E* is a bit of cork, cut into the form of a ſpider, with legs of linen thread, fixed into it by drawing them through with a ſmall needle, and then they are cut with ſciſſars to a proper length. It is hung by a fine ſilk thread to the cieling of the room, and at ſuch a height above the table that its legs may touch the balls *C* and *D*, if it be made to ſwing between them.——Before the legs are put to it, it muſt be put upon the point

of

of a wire, and turned round and round in the flame of a candle, to burn off the roughneſs and ſharp edges which the knife had left on its ſurface; and then the burnt parts muſt be rubbed off between a wet finger and thumb, to ſmooth it.

25. In Fig. 4. *A a* is a thin glaſs, blown into the ſhape of a Florence flaſk, left open at the ſmall end *a*. A cork, through which a ſmall hole has been made by a red-hot iron wire, is cemented into this glaſs at the mouth *a*; and a narrow ſlip of thin bladder, that had been moiſtened before, is tied over the hole, by way of a valve. The glaſs is then put under a receiver on the air-pump, and exhauſted of air; then taken out, and a braſs cap *a*, in which ſome hot ſealing-wax has been poured, is put on, over the valve, to prevent any air from getting afterward into the glaſs. The inſide of this glaſs muſt be perfectly clean and dry: for, if there be

any duſt or damp within it, it will be of no uſe for an experiment.

26. Fig. 5. is the artificial *thunder-houſe*, with its appurtenances. *A* is a mahogany board, half an inch thick, and ſhaped like the gable end of a houſe, which is all that is neceſſary of the houſe for an experiment. It is fixed upright on the horizontal board or ſtand *B*, in which is alſo fixed the lower end of an upright glaſs tube *C D*; in the upper end of which, the end *D* of a crooked braſs wire *D E w F* is cemented; and on the other end of the wire is fixed the ſmooth braſs ball *F*; above which ſome downy feathers *H* are hung around the wire by linen threads, which are tied round the wire by a thread of the ſame ſort.——One end of a metal chain *IK* is hung by a hook on this wire, and the other end is hung by a hook to the fartheſt end *L* of the prime conductor of the electrical machine; and the coated jar *M* is ſo placed, in making the experiment, that the ball *m* on the

top

top of its wire may touch that end of the conductor.——A ſquare hole *a b c d*, a full quarter of an inch deep, and three quarters wide, is made in the gable-board *A*, and filled with a ſquare piece of wood *N* juſt as thick as the hole is deep; but it muſt go ſo eaſily into the hole, that it would drop out if *A* were turned over toward *B*. A wire *a N c* is put into this board, very faſt, in a diagonal channel juſt as deep as the wire is thick, ſo as never to be taken out again. And, in the ſame manner, the wires *g d* and *b h* are fixed in the gable-board, the lower end of the former being at the corner *d* of the ſquare hole, and the upper end of the latter at the oppoſite corner *b*. The wire *g d* has a braſs ball *G* on its top, directly below the ball *F*, and about half an inch from it: the wire *b h* is turned up at the lower end, in the form of a hook, on which one end of a metal chain *i k* is hooked, and the other end of the chain is put round

the bottom of the coated jar *M.*—When the square board *N* is put into the hole *a b c d* in the way represented in the figure, its diagonal wire *a N c* has no connection with the wires *g d* and *b b*: but, if it be taken out, and turned a quarter round, and then put in again, the wire *a N c* will be in the position *d N b*; and then its ends will touch the nearest ends of both the other wires at *d* and *b*, and the whole will seem as if it were only one continued wire bent at the opposite corners *b* and *d.*—This was contrived by Dr. James Lind of Edinburgh, for verifying Dr. FRANKLIN's method of preserving houses, by means of metal rods, from damage by lightning, when it breaks upon them; the rods collecting the whole of the lightning into themselves, and conducting it harmlessly down into the ground.

27. The magical picture, contrived by Mr. Kinnersley *, is made thus:

* Franklin's Letters, page 29. printed in the year 1769.

"Having

"Having a large mezzotinto with a "frame and glaſs, ſuppoſe of the KING, "(God preſerve him), take out the "print, and cut a pannel out of it, "near two inches diſtant from the "frame all around. With thin paſte, "or gum-water, fix the border that is "cut off on the inſide of the glaſs, "preſſing it ſmooth and cloſe; then "fill up the vacancy by gilding the "glaſs with leaf-gold or braſs. Gild "likewiſe the inner edge of the back "of the frame all round, except the "top part, and form a communication "between that gilding and the gild-"ing behind the glaſs; then put in "the board, and that ſide is finiſhed. "Turn up the glaſs, and gild the fore-"ſide exactly over the back-gilding, "and when it is dry, cover it, by paſt-"ing on the pannel of the picture that "had been cut out, obſerving to bring "the correſpondent parts of the border "and picture together, by which the "picture will appear of a piece, as at

 "firſt,

" first, only part is behind the glass, " and part before."

28. The stool, on which people are electrified, is a mahogany board, supported by four pillars of solid glass, each about half a foot long; but if they were eight inches in length, it would be so much the better. The edges and corners of the board ought to be well rounded off, and nothing about it left rough or sharp. —— Those who apply electricity for medical purposes, ought to have a chair, with glass feet, eight inches long, for patients to sit in, who cannot stand on a stool.

29. I shall now describe the figures on Plate 2d and 3d, which are representations of some models of machines that I have lately made; and, for the amusement of those who attend my lectures, I set these models in motion by a stream of electric fire. It must be confessed, they do not properly be-

 long

long to the claſs of electrical experiments, becauſe they might be put into motion by water, wind, or weights. Yet, as it is not unpleaſing to ſee them move by electricity, perhaps ſome gentlemen who have a mechanical turn, and are provided with electrical machines, may like to copy theſe models, both for their own amuſement and that of their friends.——All the wheels and trundle-heads are made of card-paper, the axles of common knitting wires, the trundle-ſtaves of wood, the frames (in which the ends of the axles turn round) of thick braſs wire, and the ſupporting foot of wood.——The biggeſt wheel, which reſembles the water-wheel of a common breaſt-mill, is five inches in diameter; and all the reſt of the wheels much in the ſame proportion thereto, as the figures repreſent them. The whole work is made ſo free, eaſy, and light, that a force equal to one grain weight, acting

on

on the great wheel, will put all the reſt in motion.

30. Fig. 1. of Plate 2. is a clock for ſhewing the apparent diurnal motions of the ſun and moon, with the moon's age and phaſes.——*A* is the back of the dial plate (the face of which is ſhewn by Fig. 2.); *B* the horizontal board or foot that ſupports the whole; and *C* is the great wheel which is turned by the electric ſtream, according to the order of the letters *a b c*. On the axis of the great wheel is a trundle *D*, turning the contrate wheel *E*, on whoſe axis is the trundle *F*, turning two wheels *G* and *H*; *G* having 59 teeth, and *H* 57; and theſe are the only two wheels in which the numbers of teeth need be regarded, for all the uſe of the reſt is only to put theſe two in motion. The axis of the wheel *H* is a ſhort hollow ſocket, and the wire-axis of *G* turns within it: the former of theſe carries a ſun round

the dial-plate, and the latter carries a moon round the ſame. If the ſun's motion round the dial-plate be accounted 24 hours, the moon will not go round it in leſs than 24 hours 50 minutes 32 ſeconds: for as 57 teeth are to 24 hours, ſo are 59 teeth to 24 hours 50 minutes 32 ſeconds; which is very near the truth: for the moon in the heavens is 50 minutes 28 ſeconds later in coming to the meridian every day, than ſhe was in the day before.

The face of the dial-plate (Fig. 2.) has all the 24 hours upon it; and a point from the ſun *S* ſerves for the index or hour-hand. In the middle are two round plates, equal in ſize, one directly over the other, ſo that the loweſt is hid from ſight by the uppermoſt, in a front view. The ſun *S* is a part of the loweſt plate, and the moon *M* a part of the uppermoſt; ſo that, if theſe plates be turned round, they carry

the

the ſun and moon round with them. ——The ſun's plate has a circular ſpace all around, divided into 29½ equal parts, which ſhew the days of the moon's age from change to change, and appear ſucceſſively through an opening *a b* in the upper plate; and between that opening and the center is a round hole, through which the moon's different phaſes are ſeen on the under plate, according to all the different days of her age. ——The undermoſt plate, which carries the ſun, is fixed on the hollow axis of the wheel *H* (Fig. 1.) and the uppermoſt plate, which carries the moon, is fixed on the axis of the wheel *G*: ſo that the revolutions of theſe plates will be juſt as different as the revolutions of their two wheels are; *viz.* in the time the wheel that carries the ſun makes 29½ revolutions, the wheel that carries the moon will make only 28½. And this will carry the moon ſo much ſlower round than the ſun, that ſhe will be 50 minutes 32 ſeconds

conds later in coming to the meridian, or uppermoſt XII, every day, than ſhe was on the day before; accounting each complete revolution of the ſun to be 24 hours, which includes both the day and the night: So that the moon, by going gradually off, will go round from the ſun to the ſun again in 29½ days and nights, which is the time between change and change. In each revolution of the ſun a different day of the moon's age will be ſeen through the opening *ab*; and a different phaſe of the moon will appear through the round hole.—I need not inform any clockmaker how eaſy it would be for him to have ſuch an apparent diurnal motion of the ſun and moon in a real clock.

31. Fig. 3. of Plate 2. is a kind of Orrery, for ſhewing the earth's motion round its axis in 24 hours, the age of the moon from change to change, and all her various phaſes during that time. *A* is the horizontal board or ſtand

ſtand of this machine, and *B* is the great wheel, with 18 floats or wings for the electric ſtream to act upon, and turn the wheel according to the order of the letters *a b c d*. On the axis of this wheel is a trundle *C*, of 8 ſtaves, for turning the wheel *F*, of 32 teeth, on whoſe axis is a trundle *G*, of 8 ſtaves, for turning the wheel *H*, of 59 teeth, which will go once round in the time the great wheel *A* goes 29½ times round. A light hollow globe *D*, repreſenting the earth, with its meridians, equator, tropics, polar circles and poles, is put upon the top of the axis of the great wheel *A*, and on the ſame axis is an index *E*, which goes round a ſmall dial-plate *e* of 24 hours in the time that the earth *D* turns round. And an ivory ball *I* is placed on the top of the axis of the wheel *H*, half black half white, to repreſent the moon; below which, on the ſame axis, is an index *K*, which goes round a ſmall plate *k* divided into

29½

$29\frac{1}{2}$ equal parts, for the days of the moon's age from change to change.—— So that, in the time the great wheel *A*, the earth *D*, and hour-index *E*, make $29\frac{1}{2}$ revolutions, the moon *I* and her index *K* make only 1; and in that time, by ſhewing herſelf all round to the obſervers, they ſee all her different phaſes or appearances, like thoſe of the real moon in the heavens.

32. Fig. 4. is a model of a common mill for grinding corn. *A* is the water-wheel, *B* the cog-wheel on its axis, *C* the trundle turned by that wheel, and *D* the running millſtone on the top of the axis of the trundle.—— I have made another mill (to be turned alſo by electricity) in which, inſtead of the round plate *D* for the millſtone, there is a horizontal wheel on the axis of the trundle *C* with ſpur-cogs, which turn two trundles placed on its oppoſite ſides; and on the top of each of theſe trundles' axis

is

is a round plate repreſenting a millſtone; ſo that this model has all the working parts of a double water-mill, turning two millſtones.

33. Fig. 5. is an inſtrument that I have contrived for curing the tooth-ach by means of an electrical ſhock; and I never found it to fail except when the tooth was very much ſpoiled and decayed: in which caſe, perhaps, drawing may be the only effectual cure. ——*A* is a flat ſquare piece of box-wood, about an inch broad, and a quarter of an inch thick: two longitudinal holes are made quite through it, near its oppoſite edges, through which the braſs wires *a b c* and *d e f* are put while they are ſtraight; then fixed with ſealing wax, and bent as in the figure, ſo as to receive the tooth and gum between their points *c* and *f*, which muſt not be made too ſharp, for fear of hurting the gum. When it is uſed, two chains *g* and *h* muſt be hooked to the other ends

ends of the wires. The method of uſing it will be ſhewn in the 31ſt experiment.

34. The figure on Plate III. is taken from a model of a horizontal windmill that works three pumps for raiſing water.——It was invented by an American farmer, and ſent by him to Dr. FRANKLIN, now in London, who gave me leave to copy it, as doing ſo could not any way injure the inventor, who has contrived his horizontal wheel in ſuch a manner that it will turn equally well by the wind, blowing from any point of the compaſs. But, as ſuch a wheel would not have anſwered ſo well for my electrical machine, I have, inſtead thereof, made one like that of a common mill.

A is the horizontal wheel, and *B B* its axis, on which is a crank *C*.——As this crank is turned round by the motion of the wheel, it moves the wires

D, *E*, and *F*, backward and forward, which being hooked to the tops of the wires *G*, *H*, and *I*, gives them a like motion; and they move the wires *K*, *L*, and *M*, up and down alternately, and with them the pump rods which move the piftons in the pumps *N*, *O*, and *P*.

By this ingenious method, one fingle crank works three pumps in the fame manner as is generally done by three cranks on an axis.——The invention is quite new, and feems to me to have a great deal of merit.

SEC-

SECTION IV.

How to know whether the electrical Machine be in good Order for performing the Experiments, and to make it so if it be not.

35. TAKE away both the cushion and prime conductor from the glass globe, then wipe the globe quite dry and clean with an old soft linen cloth, that has been just warmed by the fire; and then put on the cushion, making it press gently against the globe by means of the adjusting screw *F*. (Fig. 1. of Plate I.) This done, turn the globe by the winch, and hold a knuckle of any finger near the side of the globe. Then, if you hear the fire hissing from the globe, and feel it like a gentle wind blowing through a pipe against your knuckle, the machine is in

good order. But, if you neither hear nor feel any fire, take off the cuſhion, put a little candle-tallow upon it, and then rub on a little amalgama * by means of a piece of brown paper between your hand and the cuſhion: this done, put on the cuſhion again, and the machine will work much ſtronger; as you will find by turning the globe, and preſenting your knuckle as before, or by placing the conductor ſo as the points *I* may be about an eighth part of an inch from the globe, and holding your knuckle near any part of the conductor whilſt you turn the globe: for then bright ſparks of electric fire will ſnap from the conductor to your knuckle, which will give a diſagreeable but not a painful ſenſation.

* This amalgama is made with two ounces of quickſilver, and one ounce of tinfoil, or of pewter-ſhavings, well mixt together with a ſmall quantity of powdered chalk, by beating them with a marble peſtle in a marble mortar, the peſtle having been firſt made warm.——This was Mr. Canton's invention.

36. In working the machine, the globe muſt be often wiped, and ſo muſt the prime conductor and jars, &c. to clear them of all damps and duſt; eſpecially if there be much company in the room: for damps and duſt ſpoil the experiments, eſpecially when any of them come upon the glaſs tube *L* that inſulates the conductor.

37. When any of the amalgama ſticks to the globe, it muſt be picked off. ——When the working of the globe has made the amalgama ſmooth and gloſſy, the cuſhion muſt be taken off, and rubbed with a piece of rough brown paper, to take off the poliſh. ——And when amalgama has been put on three or four times, at different times of uſing the machine, it will form into a hard cruſt on the cuſhion, and there will be no occaſion to uſe any more afterwards: only, when the globe has made the ſurface ſmooth and gloſſy

 again,

again, take off the cuſhion, and rub it to a rough ſurface by brown paper.

38. Sometimes, eſpecially in very dry weather, it is neceſſary to take off the leather from the cuſhion, and moiſten the back of the leather a little by a wet ſponge. For, although the experiments will not ſucceed if either the globe, conductor, or jars be damp, they will not if the leather of the cuſhion be perfectly dry; becauſe, as all the fire comes from the earth to the globe by the cuſhion, and moiſture is a good conductor of this fire, it muſt come in the greateſt quantity when it finds the beſt conductor.——I generally uſe a piece of leather, with the amalgama upon it, put in looſe between the leather of the cuſhion and the globe; becauſe it may be eaſily drawn out, and rubbed or moiſtened, without taking off the cuſhion.

39. One day, laſt ſummer, when the weather had continued long dry and warm, I could not make my electrical machine work at all, either by rubbing the cuſhion, moiſtening its leather, or putting mcre amalgama thereon. For both the earth and floor of the room were ſo dry, that no electric fire could come to the cuſhion. I then dipt a hempen cord in water, tied one end of it to the braſs ſpring that ſupports the cuſhion, and put the cord out at the window to the ground, under a large water-tub, which by conſtantly dripping had well moiſtened that part of the ground; and then the machine did very well.——I afterward told this circumſtance to Dr. FRANKLIN, and he informed me that he had often, at Philadelphia, when the weather and ground were very dry, been obliged to put one end of a long wire down into his pump, and hook the other end to the cuſhion; and then he had fire enough to his electrical machine.

40. If the coated jars (§ 23, 24, 26.) be warmed a little before they are uſed, the experiments made by them will ſucceed the better.

41. The machine always works beſt when the air is in the moſt denſe ſtate, which is when it is heavieſt; and it is always ſo when the quickſilver in the barometer is at the higheſt. ——When the air is light, as it always is in wet or hazy weather, the electrical experiments do not ſucceed ſo well, for want of a ſufficient reſiſtance againſt the ſurface of the prime conductor, &c. to keep the electric fire condenſed therein until it be drawn off by ſome other conducting body.——If there were no air round the prime conductor, the fire would fly from all parts of its ſurface to the walls of the room.

SEC-

SECTION V.

How to make the electrical Experiments, and to preserve Buildings from Damage by Lightning.

EXPERIMENT I.

Electric Attraction.

42. TIE one end of a fine linen thread to a ſmall downy feather, and let the other end hang down to the table. Then turn the globe of the machine by the winch; and, holding the feather near the ball *G* of the prime conductor, the feather will fly to the ball, and adhere to it as long as you keep working the machine *.

* The feather and prime conductor attract each other (we ſuppoſe) in proportion to their weights or quantities of matter: but the conductor, being heavy, cannot be ſenſibly moved by the attraction of the light feather.

As

As faſt as the feather receives the electric fire from the prime conductor, the fire runs off from the feather by the thread to the table, or to the hand that holds the thread. So that, although the feather is ſtill receiving new fire, it parts with it as faſt; and therefore there is no increaſe of its natural quantity: if there were, the feather would then be repelled from the prime conductor. *See Sect.* I. §. 5, 6, and 9.

EXPERIMENT II.

Electric Attraction.

43. Make a ring of wire, at leaſt a foot larger in diameter than the glaſs globe of the machine, and tie pieces of fine linen threads to it, each about five inches long, and about two inches from each other. Then, having taken away the conductor *G H*, hold the ring in

in a horizontal poſition round the globe, and turn the globe by the winch. As ſoon as the globe begins to turn round, all the threads will be attracted toward it, and point toward its center, ſtanding horizontally inward, and reſembling the radii or ſpokes of a wheel.

The perſon who holds the ring (*Sect.* I. § 3.) carries off the electric fire from the threads and ring as faſt as they receive it from the globe: and ſo they remain attracted by the globe as long as it is kept in motion, and brings fire from the cuſhion to the threads.

EXPERIMENT III.

Electric Repulſion.

44. Stick the wire *N* into the ball *G* of the prime conductor (Fig. 1. of Plate I.), and place the conductor ſo as the points *I* may almoſt touch the glaſs globe *A* of

of the machine. Then take the two little pith-balls *O* and *P* (§ 16.) and hang them by the thread upon the wire, ſo as the middle of the thread may be upon the wire, and the balls will hang cloſe together, keeping the two parts of the thread perpendicular to the table, by means of their little weight. But turn the glaſs globe by the winch, to electrify the balls, and they will repel each other, and ſtand apart, as in the figure; and continue ſo as long as you keep turning.

The balls having nothing to draw off the fire from them which they receive from the machine, they are both electrified poſitively; and cannot diſſipate the fire ſo faſt around them in the air as they receive it: and therefore, they acquire a quantity of fire beyond that which they had in their natural ſtate; and ſo they repel each other, according to § 6 and 7.

EXPE-

EXPERIMENT IV.

That Metals are Conductors of Electric Fire, and Wax is not.

45. While the balls ſtand aſunder, and you keep turning the machine, touch any part of the prime conductor by a piece of metal; and the balls *O* and *P* will inſtantly come cloſe together: which ſhews that the electic fire runs off by the metal. But touch the prime conductor by a ſtick of wax (or by any piece of glaſs) and the balls will ſtill keep aſunder as before: which ſhews that wax and glaſs are non-conductors, as none of the electric fluid is drawn off by them.

N. B. Theſe balls are very good for trying the ſtrength of the electrical machine, which may be done as follows: ——Remove the prime conductor, and every other part of the electric apparatus, from the table, three feet at leaſt from

from the glaſs globe of the machine. Then turn the globe by the winch, and hang the balls by the middle of the double thread about two feet from the globe. If they begin to ſeparate from each other at that diſtance, the machine is in very good order; but if they do not, bring them gradually nearer, until you ſee them begin to ſeparate. And wherever they do, it ſhews that the air is electrified to that diſtance, all around the globe.

EXPERIMENT V.

The Electrical Fly.

46. The prime conductor being ſet properly to the globe, (as in Fig. I.) and every thing at a proper diſtance from it *, put the blunt end of the crooked wire *c d* into the hole in the top of the ball *G* of the prime conductor (§ 17.);

* When any thing is to be electrified, every other thing ought to be ſet one foot from it at leaſt.

and

and hang the fly *e f g h i k* upon the ſharp-pointed top of the wire. Then turn the globe by the winch, and the fly will turn round, with a very briſk motion, in a contrary direction to the way that its points are bent, or according to the order of the letters *e f g h i k*. —— If this experiment be made in a dark room, the moment when the globe of the machine begins to be turned, a bright ſpark of electric fire will appear at each point of the fly; and when it acquires a quick motion, theſe ſparks will form a complete luminous ring.

To account for this motion of the fly, ſuppoſe its arms to be ſtraight hollow tubes, open throughout. Then, if water were forced into them from the center, it would run out at the open ends, fartheſt from the center. In this caſe, the preſſure of the water againſt the inſide ſurfaces of the tubes, being equal all around, could excite no motion in the fly. But if the tubes are all

all bent one way, near their outermoſt ends, there will be a preſſure againſt the inſides of the bended parts, and no preſſure oppoſite to them at the open ends where the water ſpouts out: and therefore, the preſſure againſt the inſides of the bendings will cauſe the fly to turn round that way.

The electric fluid (like water in tubes) runs from the wire *c d* into the ſubſtance of the metal arms of the fly, and goes off freely from their points. If theſe arms were ſtraight, the fly would not move . but being bent, it muſt turn round, as a fly of bended tubes would do if water were forced into them at the center.

EXPERIMENT VI.

The ringing of bells.

47. Hang the hook *Q* upon the prime conductor, and the lower part of the chain *W* that hangs from the middle

middle bell *S* (§ 18) will lie upon the table. Then turn the globe by the winch, and the clappers *U* and *V* will fly from bell to bell with a very quick motion; and all the three bells, *R*, *S*, and *T*, will continue to ring as long as you keep turning the globe. In a darkened room, ſparks of electric fire will be ſeen between the clappers and bells.

The two bells *R* and *T*, being hung by metal chains, are electrified from the prime conductor; but the middle bell *S*, and the two clappers *U* and *V*, being hung by ſilk lines, cannot be electrified thereby (§ 3), becauſe the ſilk tranſmits no fire from the conductor to them. The outſide bells, being electrified, attract the unelectrified clappers, and depoſite part of their fire upon them. The clappers, being then electrified as well as the bells, are repelled from them to the unelectrified middle bell, which takes the fire from them the moment they touch it; and that fire immediately

runs

runs off from the middle bell, by the chain *W*, to the table. The clappers being then unelectrified (as well as the middle bell), they are attracted back again to the two electrified bells *R* and *T*, and being then again electrified, they are repelled from these bells (as before) toward the middle bell. And thus the ringing must continue as long as the outside bells are kept in an electrified state by the machine.

If a person takes hold of the chain *W*, and lifts it up from the table, the ringing will continue, because he (being a conductor, § 3.) will draw off the fire from the middle bell, as the table did, as fast as it receives the fire from the clappers. But if he takes hold of the silk cord *w*, which is fixed to the lower end of the chain *W*, and thereby raises the chain from the table, the ringing will immediately stop, which shews that silk is a non-conductor of electric fire, and so stops that fire from running off

from

from the middle bell; which having its natural quantity before, will receive no additional quantity, unlefs that quantity be allowed to run off.

If the middle bell were hung by a metal chain, as the outfide bells are, they would be all equally electrified from the prime conductor; and then, as the clappers would be equally attracted on both their fides by the three bells, they could not move toward either fide; and therefore they would hang motionlefs.

EXPERIMENT VII.

Drawing off Streams of Electric Fire.

48. Hang the thin brafs-plate *X* (§ 19.) upon the prime conductor, and darken the room. Then turn the glafs globe of the machine by the winch, and hold your knuckles near the edge of the plate; and you will fee ftreams of

fire iſſuing from the plate to your knuckles, and feel it like a gentle wind. If you move your hand round the edge of the plate, the fire will follow your hand, and come to it.

The knuckles, being conductors, draw off the fire from the electrified plate.

EXPERIMENT VIII.

Dancing of Electrified Bran, Images, &c.

49. Set the braſs-plate *Y* (§ 19.) directly under the plate *X*, and about two or three inches from it, as you will ſoon find by experience what diſtance is beſt. Then put a little dry ſand, bran, or pollard, upon the plate *Y*. This done, turn the globe by the winch; and the ſand or bran will move up and down with a ſurpriſing rapidity between the plates, ſo that you cannot diſtinguiſh the particles, but the whole will look like a white miſt.

Or,

Or, put ſome little images, of cut paper, between the plates; and when you turn the globe, the images will dance, between the plates, in ſuch antick poſtures as will probably make a whole company laugh, that had never ſeen the experiment before.

All this depends upon the ſame principle as the 6th experiment; the bran or images being attracted and repelled as the clappers were, between the bells.——If the images and bells be uſed at the ſame time, it will ſeem as if the former danced to the muſic of the latter.

EXPERIMENT IX.

Dancing of electrified Cotton.

50. Turn the globe by the winch with one hand, and hold the other about three or four inches from the end *G* of the prime conductor. While you are

doing this, deſire any perſon to let a ſmall lock of cotton drop from his hand upon yours which is near the conductor; and the cotton will jump from your hand to the conductor. and back to your hand again, with a quick motion, ſtretching itſelf out into a longiſh form both ways, and moving ſo quick that you will not well be able to perceive its form, and can only ſee its colour.

This depends upon the ſame principle of attraction and repulſion as ſhewn in the 6th experiment; for the electrified conductor attracts the unelectrified cotton, which becomes electrified on touching the conductor, and is then repelled from it to the hand, which unelectrifies it, by drawing off the additional fire that the conductor had given it juſt before; and then, being unelectrified, it is again attracted by the electrified conductor.

EXPE-

EXPERIMENT X.

The Electrified Feather.

51. Stick the plumy feather *b* (§ 20.) into the prime conductor, and turn the globe as above.——The feather will then be all electrified alike; and its *plumulæ* will repel each other, and ſtand briſtling out from the rib of the feather. Then, if any part of the conductor be touched by a finger, or piece of metal, it will draw off the fire that way, and the feather will immediately ſhrink; or it will do the ſame if the point of a needle or wire be held near it, or near the prime conductor; which ſhews that pointed metals draw off the electric fire. But if the point of a finger, or any piece of round metal, be held near the feather, it will come to the finger or metal, and cling round it: and if either of theſe be moved round the fea-

ther, it will bend about, and follow the moving body.

The firſt part of this experiment ſhews electric repulſion; and the laſt part, electric attraction, as in the 3d, 1ſt, and 2d experiments.

EXPERIMENT XI.

Water Electrified in a Cup.

52. Take a metal cup, that has a bow to it over its top; fill it almoſt full of water, and hang it upon the prime conductor, as high from the table as can be, and remove every other part of the apparatus to a good diſtance from it. Then turn the globe by the winch to electrify the water, and hold a finger, pointing perpendicularly downward, over the middle of the ſurface of the water, and very near it. The electrified water will then riſe up, in the form of a cone, toward the end of

of the unelectrified finger; which ſhews that an unelectrified body, if it be of the conducting kind, will attract an electrified one.——In a dark room, a ſtream of fire will be ſeen iſſuing from the water to the finger; which ſhews that water is a conductor of electric fire. *See* § 3.

EXPERIMENT XII.

The Electrified Water-jet.

53. Hang the leg *A* of a ſmall glaſs ſyphon, (Fig. 6. of Plate 2.) into the water in the cup, the other end *B* of the ſyphon having been turned a little upward, and drawn out into a ſmall capillary bore. Put your mouth to the end *B*, and draw the air out of the ſyphon, and then the water will follow, and fall from the ſyphon in drops.—But, turn the globe by the winch, to electrify the water, and it will fly to a good diſtance from the end *B* of the

 ſyphon,

ſyphon, in one continued jet, which will have the appearance of fire if the room be darkened. If an unelectrified perſon puts his finger, or any piece of metal, upon the prime conductor, the fire will immediately ceaſe, and the jet will ſtop; but when the finger or metal is taken away from the conductor, the fire will appear again, and the jet will fly out as before.

From this it ſhould ſeem, that when a perſon's blood circulates too ſlow, electrifying him would quicken the circulation. And I have heard, that when a vein has been opened by a lancet, and the blood only dropt from it, electrifying the perſon has cauſed the blood to run in a briſk ſtream.——But I never ſaw the experiment tried. The method of electrifying people will be ſhown in the 18th experiment.

EXPERIMENT XIII.

A Clock put in Motion by Electricity.

54. Put the end *A* of the crooked wire *ABC* (Fig. 6. of Plate I.) into the hole next above *G* (Fig. 1.), in the end of the prime conductor; and place the wire ſo, as that its ſharp point *C* may be juſt as high from the table as the great wheel of the clock (Fig. 1. of Plate 2.) is. Then place the clock ſo on the table as that the point of the wire may be about an inch from the wings of the wheel; and in ſuch a direction, that if the wire were hollow, and wind were blown through it, the wind might turn the wheel according to the order of the letters *a b c*. Then turn the globe of the electrical machine by the winch, and the clock will be put into motion by the ſmall force of the electric ſtream thrown off by the point of the wire againſt the wings of the wheel;

wheel; and the ſun and moon will be carried round the dial-plate (the face of which is repreſented by Fig. 2.) ſo as to ſhew their apparent diurnal motions, the different ages and phaſes of the moon (as deſcribed in § 30.), and the time of her coming to the meridian every day of her age, accounted from any change to the next change after it.

EXPERIMENT XIV.

A ſimple Orrery put into Motion by Electricity.

55. Having ſet the orrery (§ 31.—— Fig. 2. of Plate 2.) properly, near the prime conductor, and placed the abovementioned crooked wire ſo as its point may be even with the great wheel *B*, and tend to turn it in the direction *a b c d*; turn the glaſs globe of the electrical machine by the winch, and a ſtream of fire will iſſue from the wire to the wheel, and turn the whole of the

the moveable work: by which means, the earth *D* will be turned round its axis, from weſt, by ſouth, to eaſt; and, in each turn of the earth, the index *E* will go round all the 24 hours on the dial-plate *e* *.——In the time the earth and index turns 29½ times round, the moon *I* will turn once round her axis, ſhewing all her various phaſes; and the index *K* will go over all the 29½ days of the moon's age on the plate *k*.

EXPERIMENT XV.

A Model of a Water-mill turned by a Stream of Electric Fire.

56. Set the mill (§ 32.——Fig 3. of Plate 2.) properly, near the prime conductor, and place the crooked wire ſo as its point may be directed toward the uppermoſt ſide of the great wheel *A*.

* By a miſtake in the engraving, the hours are numbered the wrong way round this plate.

Then

Then turn the glaſs globe by the winch, and the ſtream of fire that iſſues from the point of the wire will turn the wheel; and, conſequently, all the other working parts of the mill.

I have often found, that either of theſe machines will be put into motion when the point of the crooked wire is four inches from the wings of the great wheel. And yet my electrical machine is far from being one of the ſtrongeſt kind.

EXPERIMENT XVI.

A Model of a triple Pump-mill (for raiſing Water by the Force of the Wind) put into Motion by Electricity.

57. Set the mill (Plate 3.) deſcribed in § 34. properly, near the prime conductor, and place the crooked wire ſo therein as its point may be directed

toward the wings of the wheel *A*. Then turn the glaſs globe by the winch, and the ſtream of electric fire that iſſues from the point will turn the wheel; and conſequently, the pump-rods will be alternately moved up and down in the pumps *N*, *O*, and *P*.

EXPERIMENT XVII.

The luminous Glaſs, or Aurora Borealis.

58. This is one of the fineſt of all electrical experiments, and owes its invention to Mr. JOHN CANTON.—— Take the glaſs *A a* (Fig. 4. of Plate I.) by either of its ends, and hold the other end to the prime conductor. Then make the room quite dark, and turn the globe of the machine by the winch. On doing this, the glaſs will be full of electric fire, which will ſtream and flaſh, exactly reſembling the *Aurora Borealis*, or northern lights

in

in the heavens; and the flaſhing will continue for ſome time after the glaſs is removed from the conductor. When the flaſhing ceaſes, and you continue to hold the glaſs by either end in one hand, apply the palm of the other hand to the other end of the glaſs, and the fire will appear within it again.—— The method of preparing this glaſs is ſhewn in § 25.

The fire is always within the glaſs, but adheres inviſibly to it until it is thrown off therefrom, and put into action by electrifying, or by rubbing. ——It is plain that it is not the electric fire from the machine that goes through the glaſs and appears within it; for after it has been ever ſo long from the conductor, if it be rubbed on the outſide by a dry hand, it will be luminous within. If it were not very nearly exhauſted of air, ſo as to leave the ſmall quantity within it rare and thin, it could not be made luminous either by means of the elec-

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trical machine, or by rubbing: which ſhews that air acts againſt the electrical fire, and keeps it the longer from flying off, at the ſurfaces of bodies.

EXPERIMENT XVIII.

Electric Sparks taken from the Prime Conductor.

59. While the globe is turned by the winch, the points *I* (Fig. 1. of Plate I.) attract the fire from the globe to the prime conductor, wherein the fire becomes accumulated and condenſed, when there is no other conductor therefrom to carry the fire to the ground. But if any perſon, ſtanding on the floor, holds a knuckle of any finger near the conductor, as ſuppoſe about an inch from it, the condenſed fire will ſnap from the conductor in large ſparks to his knuckle; and give him rather a diſagreeable than painful ſenſation: and as

faſt as the fire flies to his knuckle, it runs off by his arms and body to the ground. If he holds his knuckle very near the conductor, he will not feel the fire ſo ſharp, becauſe he has it more gradually, and in a conſtant ſmall ſtream: and if he puts his finger upon the conductor, he will not feel the fire in the leaſt, although he receives it juſt as faſt from the conductor as it is given thereto by the globe.

EXPERIMENT XIX.

Electric Sparks taken from the human Body.

60. Having warmed the glaſs-footed ſtool (§ 28.) a little by the fire, and wiped it all over to clear it of duſt, ſet it upon the floor, and let any perſon ſtand upon it, holding one end of a chain (or rather of a wire), the other end of which is hooked to the prime

conductor; the chain or wire being held up at some distance from the table; and no chair, table, or person in the room being within a foot of the person who stands on the stool. Then turn the glass globe of the machine by the winch, and all the fire that the prime conductor receives from the globe will be conducted from it by the chain or wire to the person on the stool; and he will be strongly electrified, without feeling any thing from the fire he receives, unless some person who stands on the floor touches him any where with the finger; and if he does, all the fire will snap against his finger from the electrified person, and both these persons will feel it smartly, but it will do no harm to either of them.——By this method, all the electric fire, which a person receives while he stands on the stool, may be drawn off from any part of his body that is touched by a person standing on the ground. But the person who touches, should present his

finger or knuckle very briſkly each time, and withdraw it quickly each time he takes off the ſpark.

In this experiment, the perſon on the ſtool may be conſidered as part of the prime conductor; for he is connected with it by means of a wire or chain, and the glaſs feet of the ſtool cuts off all electric communication between him and the ground; ſo that he retains the fire till it be drawn off from any part of his body, as it was drawn off from the prime conductor itſelf in the 17th experiment. And the glaſs tube *L*, on which the prime conductor is ſupported, cuts off all electric communication between it and the table. If it were ſupported by any ſubſtance (§ 3.) that conducts the electric virtue, no ſparks could be taken from it, nor could any thing be electrified by it, for all the electric matter would run from it by the conducting ſubſtance to the table and ground, as faſt as it

re-

received that matter or virtue from the globe.

If a ſmooth ball of metal be fixed on one end of a long thick wire, and the perſon who is electrified on the ſtool hold the other end of the wire in his hand, and touches any other perſon in the company with the ball, the fire will ſnap from the ball to that perſon, and he will feel it ſmartly; but the perſon who holds the wire will ſcarce feel any ſenſation from the fire.

EXPERIMENT XX.

The Electrical Kiſs.

61. Suppoſe the two above-mentioned perſons be a gentleman and a lady. Let either of them be electrified on the glaſs-footed ſtool, whilſt the other ſtands at a little diſtance on the floor, ſo that the clothes of the

 one

one may not touch the clothes of the other. Then, if they incline their heads, and offer to ſalute each other, the fire will ſnap from the lips of the electrified perſon to thoſe of the other, and will give them both ſuch a ſmart and mutual rebuff, as will make them ſeparate without being able to accompliſh their deſign, unleſs they have been appriſed of the conſequence before, and have reſolution enough to bear the ſmart of the electric fire.——In this experiment, nothing but the lips ſhould touch; for, if the gentleman puts his hand upon the lady, it will draw off the fire.

EXPERIMENT XXI.

Setting Spirits of Wine on Fire.

62. Let one perſon be electrified, as in the laſt experiment, while another ſtands at ſome diſtance on the floor. If either of them holds a ſilver ſpoon with ſome

ſome rectified ſpirits of wine in it, and warms the ſpirits a little, by holding the ſpoon over the flame of a candle, and the other perſon then preſents the tip of his finger briſkly toward the ſpirits, a ſnap of electric fire will enſue, which will ſet the ſpirits all in a flame directly.——The perſon who preſents his finger muſt withdraw it immediately, leſt the flame ſhould hurt him.

EXPERIMENT XXII.

The diverging Electrical Flame.

63. Let the perſon electrified on the ſtool hold a ſword in his hand, or any other pointed piece of metal that is well poliſhed. Then, if the room be darkened, a bluiſh flame will be ſeen to iſſue, in a diverging ſtate, from the point, and continue as long as the globe of the machine is turned by the winch, unleſs ſome perſon ſtanding on the floor touches

him who holds the ſword; and if this be done, the flame will immediately diſappear, becauſe the perſon who touches, draws off all the electric virtue from him who holds the ſword. The ſame will happen, if a perſon ſtanding on the floor put his finger upon the prime conductor; but the moment he withdraws his finger the flame will appear again.

EXPERIMENT XXIII.

The Diadem of Beatification.

64. Put a hoop of leather that is ſilvered and lackered round a perſon's head, and let him be electrified on the glaſs-footed ſtool; then let a perſon ſtanding on the floor hold the tips of his fingers near the hoop, moving them round and round it, and briſk flaſhes of electric lightning will come from the

ſhoop to the fingers, and be felt like a gentle cool breeze of wind.

EXPERIMENT XXIV.

Giving a Shock to the Teeth.

65. Let the electrified perſon hold a piece of money between his teeth, and a perſon ſtanding on the floor touch it: the ſhock will be ſo ſtrong as will probably make him drop the money, eſpecially if his lips do not touch it.

EXPERIMENT XXV.

That an electrified Perſon may be conſidered as an additional Part to the Prime Conductor.

66. Let the fly *e f g h i k* (*Exp.* V.) be hung upon the ſharp point of the crooked

crooked wire *c d* (Fig. 1. of Plate I.), and a perſon electrified on the glaſs ſtool hold the wire by the other end in his hand. Then, as long as the glaſs globe is turned by the winch, the fly will turn round with as quick a motion as it did when the wire was ſtuck into the prime conductor, in the 5th experiment.

EXPERIMENT XXVI.

Charging and diſcharging coated Glaſs Jars.

67. Place the jar *A* (§ 23.——Fig. 2. of Plate I.) ſo on the table, that the ball *a*, on the top of its wire, may be about the eighth part of an inch from the ball *G* (Fig. 1.) of the prime conductor. Then turn the glaſs globe of the machine by the winch, and all the electric fire, which the points *I* take from the globe to the conductor will fly

fly from its ball *G* to the ball *a* of the jar, and thence it will run down the wire to the lining on the bottom of the jar, and diffuſe itſelf all over the inſide of the jar as far as the lining goes, and will be accumulated and condenſed there in the glaſs.——Continue turning, as long as you ſee the fire between the prime conductor and ball *a* of the jar; and when the fire ceaſes, you may leave off turning, for the jar has got its full charge, and can receive no more, if you ſhould continue to turn ever ſo long afterward. ——This done, take hold of the diſcharger *B* (Fig. 2.) by the middle, and firſt apply the knob *b* (on the lower end of the diſcharger) to the outſide of the jar near the bottom; and keeping it there, put the upper knob *c* to the ball *a* of the jar wire, and the jar will be diſcharged of its fire, with a loud ſnap; but the perſon who holds the diſcharger will feel nothing from the fire.

The jar has no more fire when it is charged than what it had before; for the metal coating conducts juſt as much fire from its outſide to the table and ground, as the prime conductor threw into its inſide by the wire and the metal lining; by which means, the inſide is electrified *plus* (§ 6.), and the outſide *minus*——So that what we here call charging, is only forcing more fire into the inſide than it naturally had, (§ 2. and 4) whilſt the table carries off juſt as much of the natural quantity from the outſide by the coating. And what we call diſcharging, is only making a conducting communication between the lining and coating of the jar, by means of the bended wire *B*, through which the accumulated fire flies from the ſurcharged inſide to the vacant outſide of the jar, and ſo reſtores the equilibrium; which could not have been reſtored if the outſide had not loſt as much as was forced into the inſide.

When

When the jar is charged, a perſon may take hold of it very ſafely with one hand, by the coating near the bottom, and ſet it down upon any other part of the table before he diſcharges it. But he muſt be careful not to touch the ball *a* with his other hand: for, if he does, he will act the part of a diſcharger himſelf, and receive the whole fire of the jar through his arms and breaſt; which will not only give him a violent ſhock, but will alſo endanger the jar; for if he lets it drop from his hand, it may be broke by the fall.

In charging the jar, eſpecially if it be large, it ſhould be ſet upon a pewter plate; that when it is to be diſcharged, the lower knob of the bended wire *B* may be applied to the edge of the plate, before the upper knob be applied to the ball *a* of the jar-wire. For then the fire will be diffuſed all over the plate, and go equally to all

parts

parts of the outſide of the jar by the coating.——Experience has taught me this,—having found, that when all the diſcharged fire has ſtruck upon one point of the outſide, it has made a hole quite through the coating, glaſs, and lining: and when this happens, the jar is rendered uſeleſs.

I have ſometimes found, that although a jar received the fire very freely into its inſide from the prime conductor, yet it could not be in the leaſt charged thereby. For, on applying the diſcharger *B*, there was no flaſh. And always, on ſtripping off the coating from ſuch a jar, I have found the glaſs to be cracked or rent. So that, all the electric virtue, which the inſide had received from the machine, run through the crack to the outſide, and was carried off by the coating and table.——This (I think) ſhews very plainly, that the electric fluid cannot paſs through ſound glaſs, unleſs it comes with a force

ſufficient

ſufficient to break it, as lightning often breaks glaſs-windows.

EXPERIMENT XXVII.

Shewing, that in charging a Jar, as much Fire is carried off from its Outſide by the Coating, as is thrown into its Inſide by the Lining.

68. Put a crooked wire, as *de* (Fig. 3. of Plate I.) into a hole in the top of the ball *D*, which is fixed on the top of the bended wire *B* (*See* § 24.): the point *e* of the wire *d e* being made ſharp, and of equal height with the top of the great wheel *A* of the mill (Fig. 4. of Plate II.), which, in the 15th experiment, was turned by a ſtream of electric fire, from the point *C* of the crooked wire (Fig. 6. of Plate I.), when the blunt end *A* was ſtuck into a hole in the prime conductor——Things being thus prepared, ſet the jar *A* (Fig. 3.

of

of Plate I.) upon a large pane of glaſs, dry and free from duſt; which will cut off all electric communication between the jar and the table. And let the jar and mill be ſo placed, that the ball *C* of the jar-wire may be within the eighth part of an inch of the prime conductor; and the wings of the great wheel of the mill about an inch from the point *e* of the additional bended wire *d e*. Then turn the glaſs globe of the electrical machine by the winch, to charge the inſide of the jar; and the electric fire from the outſide will go off from the coating, by the wire *B D d e*, and turn the mill the ſame way, and with the ſame velocity, as it was turned in the 15th experiment by the fire directly from the prime conductor. When the jar has received its full charge, and no more fire appears between the ball *C* and the prime conductor, the mill will ſtop. But diſcharge the jar, as in the foregoing experiment, and begin to charge it again; and then the mill will begin to

go, and continue going till the jar has got its full charge.

This proves, to a demonſtration, that the electric fire goes as faſt from the outſide of the jar, as the machine throws it into the inſide. For the wire *B*, that goes from the outſide coating to the mill, has no communication either with the inſide of the jar or with the prime conductor. And that the outſide has parted with all its natural quantity of fire (or at leaſt with as much as the inſide had received from the machine); ſeeing that the mill ſtops when the fire ceaſes to go from the prime conductor into the jar.

If the jar be placed on the table, without having the pane of glaſs between it and the table, the mill will not be put into motion by charging the jar; which ſhews that the fire runs off from its outſide to the table, as faſt as the machine throws fire into its inſide.

EXPERIMENT XXVIII.

Striking a Hole through a Card.

69. Having charged the jar *A* (Fig. 2.) as in the 24th experiment, hold a card with one hand cloſe to the coating of the jar near the bottom. Then apply the loweſt knob of the diſcharger *B* to the card, and keeping it there, put the uppermoſt knob to the ball of the jar-wire; and the whole contents of the jar will be diſcharged through the card, and will make a hole thro' that part of it; and it will have a ſtrong ſulphureous, or rather phoſphoreal ſmell.

Dr. FRANKLIN has ſhewn, that electric fire is the very ſame with that of lightning from the thunder-clouds; for he has drawn it from them, and charged his jars therewith, and found all

all the effects of discharging to be the same as if the jars had been charged by the electrical machine.——No wonder then, if the small quantity that a jar can hold will strike a hole through a card, or even through a quire of paper, if the jar be large, that the lightning from a cloud whose surface is equal to several hundred acres should tear trees or destroy buildings, when it breaks upon them.——Lightning kills animals and melts metals: the same has been done by electricity.——Lightning smells like sulphur or phosphorus where it breaks; and electric fire does the same.

Dr. James Lind at Edinburgh has put up a long rod, with a wire twisted round it, on one of the chimneys of his house, and hooked one end of a long chain to the foot of the rod at the chimney-top, letting the other end go down into the ground. From any convenient part of the chain, he brings a wire to a coated jar in his room.

 When

When a thunder-cloud paſſes over the houſe, the lightning comes ſilently from it to the rod, and is conducted down by the wire twiſted round it, to the chain, which conducts the greateſt part of the lightning ſilently down to the earth, although a ſufficient quantity thereof will go by the croſs wire from the chain to his electric jars; and when they are fully charged, no more of the lightning can go that way. — I have ſeen him charge them by that method, and diſcharge them in the common way; all the ſame as when he charged them by his electrical machine.

He has alſo connected a ſet of bells (See Exp. 6.) after Dr. FRANKLIN's method, with a wire from his chain, and inſulated them by hanging the hook Q upon a tube of glaſs. So that whenever a low thunder-cloud goes over his houſe, the rod draws lightning from the cloud to the bells, which ſets them a ringing, as if they

they were made to ring by electricity.

Perſons who are fond of ſhooting ought never to go out with their guns when there is any appearance of thunder.——For as all metals attract the lightning, if it ſhould happen to break upon the gun-barrel, the man who carries the gun would be in the moſt imminent danger of his life. —— If he ſees a thunder-cloud near him, the beſt thing he could do, would be to ſet the gun upright on the ground, againſt any thing which would keep it in that poſition, and run away from it as faſt as he can: and then, if the thunder ſhould happen to break upon the gun-barrel. it would all run down thereby to the ground.

As water is a cunductor of lightning, a perſon, whoſe hat, wig, and clothes were well wetted, would be in leſs danger from lightning that broke

upon his head; because the most of it would run down by his wet clothes to the ground.

No person ought to go near trees, or stand below their tops, in the time of thunder: for if it should happen to break upon the top of the tree under which he then stood, the tree would conduct the lightning to his body.

When it thunders, people in a room should always keep as far as they can from the walls; especially from that wall in which the chimney is; because, when the lightning comes down a chimney, it generally spreads about the adjoining wall.——And it would be right for them, in the time of thunder, to put the money out of their pockets and take the buckles out of their shoes. In short, they should then have no kind of metal about them if they can help it.

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EXPERIMENT XXIX.

Striking Gold Leaf into Glafs.

70. Take two flips of common window-glafs, each about an inch broad and four inches long: then take a flip of gold or filver leaf, about the breadth of a ftraw, and fix inches in length; and put it between the glaffes lengthwife, in the middle, letting the ends of the leaf hang an inch without the glaffes at each end. Tie the glaffes clofe together, by wrapping a ftrong filk thread round them, and lay them down on the table, fo as one end of the metal leaf may be in contact with the coating, at the bottom of a jar, placed fo as that it may be charged at the prime conductor. Then charge the jar, and having put one end of the difcharger upon that part of the leaf that lies without the glafs flips at their fartheft

end from the jar, apply the other end of the discharger to the ball on the top of the jar-wire; and all the fire in the jar will be discharged through the metal leaf. If the slips of glass remain whole, you will see that the leaf is missing in several places; and instead of it a metallic stain upon both the glasses, exactly alike. When they are taken asunder, you will observe that the leaf has been melted by the electric lightning; and actually driven into the very substance of the glass, as neither *aqua fortis* nor *aqua regia* will take it off.

EXPERIMENT XXX.

Giving a Person an Electric Shock.

71. Let the person put a finger of one hand to the coating of a charged jar near the bottom, and then put a finger of the other hand to the ball of the jar-wire. He will then act the part of the wire-

dis-

diſcharger, and receive a ſhock through his arms and breaſt. The whole fire in the jar running thence by the wire and his finger, through that arm and his breaſt, the neareſt way to the coating, by the other arm and finger that touched the outſide.——The perſon ought not to graſp the jar by the coating; much leſs to lift it up from the table: becauſe, in the former caſe, the ſhock might make him inadvertently puſh down the jar; and in the latter, he muſt have very great reſolution if he lets not the jar fall from his hand.

EXPERIMENT XXXI.

Confining a Shock to any Part of the Body.

72. Suppoſe it were required to confine the whole of a ſhock to that part of the arm which is between the ſhoulder and elbow. Tie one end of a

metal

metal chain to the elbow by a ribbon, or piece of ſilk cord, and put the other end round the bottom of a jar ſet to be charged at the prime conductor. Then tie one end of another chain in the ſame manner to the ſhoulder, and deſire an aſſiſtant to take hold of that chain, about a foot from the other end, holding it quite clear of the former chain, and ſo as he may conveniently ſtrike the prime conductor with the looſe end that hangs down from his hand. When the jar is charged, let the aſſiſtant ſtrike any part of the prime conductor with the looſe end of the chain; this will diſcharge the jar, and the perſon to whom the chains are tied will receive the ſhock, which will only go through the part of his arm between the chains, and he will feel it no where elſe. For the fire that flies from the jar by one chain will return to it by the other, as it always takes the neareſt courſe that it can find by the beſt conductor. And,
as

as metal conducts electric fire better than the human body does, the assistant who holds the chain will receive no shock.

If it were required to give a shock to any tooth, or part of the gum; take the machine described in § 33, and represented by Fig. 5. of Plate 2. And holding it on the gum, with the tooth between the ends *c* and *f* of the wires *a b c* and *d e f*, hook the chains *g* and *h* on the other ends of these wires; put the other end of the chain *g* round the bottom of a coated jar, and desire an assistant to hold the chain *h*, hanging down from his hand, as in the above experiment; the chains not touching one another, and both of them clear of the table. Then, having charged the jar, desire the assistant to strike the prime conductor with the loose end of the chain *h*; this will discharge the jar, and give the person a shock, which will be felt only in the tooth and gum that

that is taken in between the wires at *c* and *f*.

EXPERIMENT XXXII.

Giving a Shock to any Number of Perſons who deſire it.

73. Let all the perſons join hands, ſo as to form a ſort of chain; and ſtand ſo, as the firſt perſon at either end of the chain may hold one end of a wire in the hand that joins not, the other end of that wire being below the bottom of the jar to be charged; and the perſon at the other end of the chain may touch the prime conductor (when deſired) with the hand which the one next him has not hold of. Then charge the jar, and let the laſt perſon touch the conductor with his looſe hand; which will diſcharge the jar, and give them all a ſhock at the ſame inſtant.

As all the perſons are connected together, they form a complete diſcharger.

The

The one who holds the wire on which the jar ſtands, acts the part of the end *b* (Fig. 2. of Plate I.) of the diſcharging wire that touches the bottom of the jar: and the perſon who touches the prime conductor (which is the ſame in effect as if he had touched the ball *a* of the jar-wire) acts the part of the end *c* of the diſcharging wire that touches the ball *a*. —— The reaſon why all the perſons feel the ſhock at the ſame inſtant may be underſtood by reading the ſecond, third, and fourth paragraphs of the firſt ſection.

If a baſon of water be placed between every two of the perſons who deſire to have a ſhock, they will have no occaſion to join hands, nor even to touch one another, but only to dip the fingers of the hands in water that otherwiſe would have joined. And when the jar is diſcharged, they will all receive a ſhock.

And, if there were as many canals of water (each as long as that in St. James's park)

park) as there are perſons who want to take the ſhock; and theſe canals ſo ſituated as to form a kind of circle, and their neighbouring ends had about three feet of ſolid ground betwixt them, and perſons ſtanding on theſe intervals of ground ſhould put one of their hands in the water on the right ſide, and the other hand into the water on the left, it will anſwer as well as if they had ſtood cloſe, and joined hands as above.——Dr. Watſon has given an electric ſhock to two perſons who were two miles diſtant from each other; and who, by having ſtop-watches in their hands, found that they felt the ſhock at the ſame inſtant *.

* Phil. Tranſ. abridged, vol. x. p 363.

EXPE-

EXPERIMENT XXXIII.

Giving a Shock by the Magic Picture.

74. Set the face of the picture (§ 27.) to the ball *G* of the prime conductor, and turn the globe by the winch to electrify it. Then take it away, and holding it by the top of the frame, in a horizontal position, with the face upward, lay a small gilt piece of metal, made in the form of a crown, upon the head. This done, desire any person to take hold of the foot of the frame with one hand, and take off the crown with the other.——In attempting to do this, he will fail of his design; for the moment he touches the crown, he will receive a strong shock.—You must continue to hold by the top of the frame all the while, and will have nothing to fear; because none of the electric virtue with which the picture was charged can come

to your hand. But if you quit your hold, and truſt to him who holds by the foot of the frame, the ſhock will make him quit his hold; and the picture may be broke by the fall.

The picture-glaſs being coated by the gilding on both its ſides, as far as the pannel in the middle was cut out; and a communication having been formed on the lower part of the back of the border, by a ſlip of gilding between that on the back of the glaſs and on the inſide of the foot of the frame; and the perſon who holds by that part of the frame touches the gilding there with his fingers, and the crown with his other hand; he receives the ſhock after the ſame manner as if he had touched the coating of a charged jar with one hand, and the ball of the jar-wire with the other; as in Exp. 28.

EXPERIMENT XXXIV.

The seemingly animated Spider.

75. Take away the crooked wire *d e* (Fig. 3. of Plate I.) from the ball *D*, and place the jar *A* so as its ball *C* may touch the prime conductor: then turn the winch to charge the jar.—— When it is charged, take hold of it by the coating, below the ring of the wire *B*, and place it so on the table as that the cork-spider *E* (§ 24.) may hang mid-way between the balls *C* and *D*, —— The spider will then begin to move from ball to ball, stretching out his legs toward each ball as he approaches it, and grasping each ball with his legs when he touches it, as if he were really animated.

The inside of the jar is electrified *plus*, or positively, and so is its wire

and ball *C*; but the outſide of the jar, and the wire *B* with its ball, are electrified *minus*, or negatively. (*See Exp.* XXIV.) —— The poſitively electrified ball *C* attracts the unelectrified ſpider, and electrifies him when he touches it: he is then repelled from that ball to the negatively electrified ball *D*; and, by his linen legs, which are conductors, he depoſites all the fire upon *D* that he had taken from *C*; and then, as the ball *D* has unelectrified him, he is again attracted by the ball *C*, which yet continues to be electrified poſitively, becauſe he had carried off but very little fire from the inſide of the jar. And thus he will continue to be alternately attracted and repelled till he has carried all the ſurcharge of fire from the inſide to the outſide of the jar; and then, having reſtored the equilibrium between both ſides, he will have done.

The

The ſilk thread *a b*, by which the ſpider is hung, being a non-conductor, makes him retain the electric virtue he received from *C* till he depoſites it upon *D*. If he had been hung by a linen thread, he would have ſtuck by the ball *C*; and as faſt as he received the electric virtue therefrom, it would have run off by the thread to the cieling of the room, and returned gradually from thence by the walls, floor, and table, to the outſide of the jar. And then the ſpider would have left that ball, and hung midway at reſt between it and the other.

EXPERIMENT XXXV.

The Uſe of pointed Metal Rods.

76. Every thing having been removed from the prime conductor, take a ſmall lock of cotton, and draw out part of it into the form of a thread, about an

inch long, and fix the end thereof by a little bit of bees-wax to the undermoſt ſide of the conductor, ſo that it may hang down therefrom, as between *Q* and *X*; and, with both your hands, pull out the reſt of the cotton till it be very thin, and hang together by little ſhreds. Then hold a needle in your left hand, keeping the point of it covered with the top of the fore-finger.——This done, turn the globe of the electrical machine by the winch, to electrify the cotton, which will make all the parts of it repel each other, and ſwell out into a larger ſize than before. Continue turning the winch, and hold the tip of the finger, that covers the needle's point, upward, below the cotton, which will then ſtretch itſelf downward to meet your finger.——But withdraw the finger to ſhew the point of the needle toward the cotton, and the cotton will immediately ſhrink upward from the point toward the prime conductor.——And thus, by alternately covering and un-

uncovering the point of the needle, the cotton will ſtretch downward and ſhrink upward, as long as you keep turning the winch. *This is one of Dr.* FRANKLIN'S *Experiments.*

When the cotton is replete with electric fire, it expands, and ſtretches itſelf toward the earth, like a cloud filled with lightning and highly electrified therewith. The unelectrified finger attracts the cotton toward it; as the thunder-cloud, being more highly electrified than the earth below it, is attracted by the earth. The point of the needle draws off the electric virtue from the cotton, and then it naturally re-aſſumes its former ſtate and figure: ſo the point of a metal rod draws off the lightning from a thunder-cloud, by which the cloud was expanded, and the metal conducts the lightning ſilently from the cloud down to the ground: and then the cloud being diveſted of its repulſive lightning, ſhrinks into a leſs ſpace by

the mutual attraction of its particles which the lightning had left; and thus makes the diſtance greater between the cloud and building, and a ſtroke therefore, leſs likely to happen.——This ſhews, that a long metal rod, whoſe lower end goes down into the ground, and its upper end terminates in a ſharp point, at ſome height (ſuppoſe five or ſix feet) above the top of the higheſt chimney of a houſe, will draw down the lightning from a thunder-cloud over the houſe, gradually and ſilently, into the earth, ſo as not to let the lightning accumulate in the cloud, to endanger the houſe by breaking thereon. Or, if ſuch a cloud comes ſuddenly over the houſe, and breaks, the rod will attract all the lightning, and conduct it into the ground, where it will harmleſsly diſperſe into the moiſt earth; and the houſe will receive no damage from it. ——This ſafety-rod may be bent at different places, to fit the wall and tiling, and may be fixed thereto with iron ſtaples,

ples, which will be ſo far from endangering the wall, that if any lightning were in it, they would draw it out to the rod.——I need not tell the public how much the world is indebted to Divine Providence for having inſpired Dr. FRANKLIN with this invention; and to him for communicating it. Experience has fully proved its utility, and no high building ſhould be without it, eſpecially ſuch as have ſteeples or ſpires.

Had there been ſuch a rod to St. Bride's church, it would have been preſerved from the great damage it lately ſuſtained by thunder.——And, as the method was publicly known before that church was ſtruck, future ages will hardly believe that it would have been repaired again and left without ſuch a ſafeguard, as it yet continues to be.

Theſe rods may be made of different pieces of metal, ſcrewed into one another; but copper is better than iron,

becauſe it will not contract ruſt, and decay in time, as iron does. Or they may be made of leaden bars, about two inches broad and half an inch thick, nailed together at the joinings; and the top part, which is ſharp-pointed, may be about two or three feet long, and made of copper.—Or, where there are leaden ſpouts on the ſides of the building, the metal needs only to go from the point to any of theſe ſpouts, and a rod or bar go from the bottom of the ſpout into the ground. So that the whole may be done at a very ſmall expence. The part of the metal that goes into the ground ſhould be turned away from the foundation of the building, and terminate in moiſt earth.

It is amazing to think how great a flaſh of lightning may be accumulated into a ſmall wire, and conducted thereby.—In confirmation of this, I ſhall here take the liberty to tranſcribe an account from Dr. FRANKLIN's book of *Experiments*

*and Obſervations on Electricity**; printed in London, A.D. 1769.

" Being" (ſays the Doctor) " in the " town of *Newbury* in *New England*, in " *November* laſt †, I was ſhewn the ef- " fect of lightning on their church, " which had been ſtruck a few months " before. The ſteeple was a ſquare " tower of wood, reaching ſeventy feet " up from the ground to the place " where the bell hung, over which " roſe a taper ſpire, of wood likewiſe, " reaching ſeventy feet higher, to the " vane of the weather-cock. Near the " bell was fixed an iron hammer to " ſtrike the hours; and from the tail " of the hammer a wire went down " through a ſmall gimlet-hole in the " floor that the bell ſtood upon, and " through a ſecond floor in like man- " ner; then horizontally under and

* Pages 162, 163, 164.

† Meaning November, in the year 1754.

" near

"near the plaiſtered cieling of that "ſecond floor, till it came near the "plaiſtered wall; then down by the "ſide of that wall to a clock, which "ſtood about twenty feet below the "bell. The wire was not bigger than "a common knitting needle. The ſpire "was ſplit all to pieces by the light-"ning, and the parts flung in all di-"rections over the ſquare in which "the church ſtood, ſo that nothing re-"mained above the bell.

"The lightning paſſed between the "hammer and the clock in the above-"mentioned wire, without hurting ei-"ther of the floors, or having any "effect upon them, (except making the "gimlet-holes, through which the wire "paſſed, a little bigger), and without "hurting the plaiſtered wall, or any "of the building, ſo far as the above-"ſaid wire and the pendulum wire of "the clock extended; which latter wire "was about the thickneſs of a gooſe-

quill,

" quill. From the end of the pendulum, quite down to the ground, the building was exceedingly rent and damaged, and ſome ſtones in the foundation-wall torn out and thrown to the diſtance of twenty or thirty feet. No part of the aforeſaid long ſmall wire, between the clock and the hammer, could be found, except about two inches that hung to the tail of the hammer, and about as much that was faſtened to the clock; the reſt being exploded, and its particles diſſipated in ſmoke and air, as gun-powder is by common fire; and had only left a black ſmutty track on the plaiſtering three or four inches broad, darkeſt in the middle, and fainteſt about the edges, all along the cieling under which it paſſed, and down the wall. Theſe were the effects and appearances on which I would only make the few following remarks.

" 1. That

" 1. That lightning, in its paſſage " through a building, will leave wood, " to paſs as far as it can in metal, " and not enter the wood again till " the conductor of metal ceaſes.—— " And the ſame I have obſerved in " other inſtances, as to walls of bricks " or ſtone.

" 2. The quantity of lightning that " paſſed through this ſteeple muſt have " been very great by its effects on the " lofty ſpire above the bell, and on the " ſquare tower all below the end of the " clock pendulum.

" 3. Great as this quantity was, it " was conducted by a ſmall wire and a " clock pendulum, without the leaſt " damage to the building ſo far as they " extended.

" 4. The pendulum rod, being of a " ſufficient thickneſs, conducted the

" lightning

" lightning without damage to itſelf;
" but the ſmall wire was utterly de-
" ſtroyed.

" 5. Though the ſmall wire was it-
" ſelf deſtroyed, yet it had conducted
" the lightning with ſafety to the
" building.

" 6. And from the whole, it ſeems
" probable, that if even ſuch a ſmall
" wire had been extended from the
" ſpindle of the vane to the earth be-
" fore the ſtorm, no damage would
" have been done to the ſteeple by that
" ſtroke of lightning, though the wire
" itſelf had been deſtroyed."——So far
Dr. FRANKLIN.

EXPE-

EXPERIMENT XXXVI.

The THUNDER-HOUSE.

77. This is the grand electrical experiment.——It confirms the truth of Dr. FRANKLIN's method of preferving houfes from damage by lightning.—— And as any other experiment would make but a poor figure if fhewn after it, we have referved it for the laft.

The whole of this part of the apparatus (Fig. 5. of Plate I.) being put together as reprefented by the figure, and as defcribed in the 26th paragraph of the 3d Section, with the diagonal wire *a N c* of the fquare piece of wood *a b c d* lying in the pofition as fhewn in the figure, and the jar *M* fet to the prime conductor; charge the jar, and con-

continue turning the globe by the winch till the jar difcharges itfelf with a flafh. While the jar is charging, the feathers *H* being electrified, they repel each other, and expand like a thunder-cloud; but the inftant when the jar difcharges itfelf, they fhrink and come together, and the fquare piece *a b c d* is driven out by the flafh of electric lightning to a good diftance from the gable-board *A*.

The jar difcharges itfelf along the metal chain *K T* and the crooked wire *E w F*; the fire fnaps from the ball *F* to the ball *G*, and thence runs down the wire *g d* to *d*; where finding no further metal conductor to carry it onward, it fpends its whole force on the fquare piece *a b c d*, and drives it out of the hole in the board *A*.——This fhews how dangerous weather-cocks are on the tops of buildings. For, when the thunder breaks upon them, the lightning is collected into the iron

ſpindle of the weather-cock, runs down to the lower end thereof, and finding no farther metal conductor, it ſpreads about, and ſpends its whole force on that part of the building. If there be iron clamps in the ſtones, near the foot of the ſpindle, and near to each other, and theſe clamps be not connected by wires, the lightning ſplits the building from clamp to clamp; as was the caſe of St. Bride's church ſteeple.

Put the ſquare piece of wood *a b c d* into its place again, ſo as the diagonal wire *a N c* may be in the poſition *d N b*; and then its ends *a* and *c* will touch the ends *d* and *b* of the two wires *g d* and *b h*, and the metal conductor *G g d N b h i k* will be complete.—— This done, turn the winch to charge the jar again; and continue turning till it diſcharges itſelf as before: and all the electric fire that it contained will go off with a flaſh, through the whole metal courſe *K I w F*, from *F* to

G,

G, and thence through *g d N b b i k* to the coating of the jar, (which fiery courſe may be ſeen in a darkened room); and the ſquare board *a b c d* will remain in its place, without being moved in the leaſt, even if it lies ever ſo eaſy in the hole. Which manifeſtly ſhews, that complete metal conductors will preſerve houſes from damage by lightning.

Take off the ball *G*, that the ſharp end of the wire within it may point toward the ball *F*. Then charge the jar, and you will hardly be able to make it diſcharge itſelf, nor will the feathers *H* expand any thing like what they did before. For the ſharp point draws off the electric fire gradually from *F*; and, in a darkened room, it will be ſeen like a quieſcent durable ſpark on the point of the wire. Which ſhews, that if a thunder-cloud be over a houſe, where there is a complete metal conductor, the point will gra-

dually draw down the lightning from the cloud, and so prevent its accumulating therein, in any sufficient quantity to break.

The glass tube *C D* insulates the wire *D E w F*, and prevents the electric fire, discharged from the jar, from running down to the table in the direction *E D C*; so that it can take no other course than what is shewn in the experiment.

SEC-

SECTION VI.

Medical Electricity.

78. A girl, about ſeven years of age, belonging to the Foundling-hoſpital, was ſeized with a rigidity of all the muſcles of her body, ſo as to be felt more like thoſe of a dead corpſe than of a living perſon; her jaws were quite locked up, and ſhe was very much emaciated. After having continued in this dreadful condition for a month, and all the uſual medicines had failed, Dr. Watſon ordered her to be electrified, which was begun about the middle of November, 1762; and continued, by intervals, till the end of January following, when every muſcle in her body was perfectly flexible and ſubſervient to her will; ſo that ſhe could ſtand, walk, and run, like other children of her age.——I happened to be at the Royal Society

when the whole account was read there, on the 10th of February 1763: and it was afterwards publiſhed in the 53[d] volume of the Philoſophical Tranſactions.

79. Mr. JALLABERT, Profeſſor of Mathematics at Geneva, mentions the cure of a palſy that he had performed on the arm of a lockſmith, which had continued fifteen years; and was occaſioned by the blow of a hammer. The method was by taking ſparks frequently from the paralytic arm, and ſometimes ſending the electric ſhock through it *.

80. Mr. Wilſon, by electricity, cured a woman of a deafneſs which had continued ſeventeen years. But he owns that he had tried the ſame experiment on ſix other deaf perſons without any ſucceſs †.

* Hiſtoire, pt. 3. p 36.
† Wilſon's Treatiſe on Electricity, p. 207.

81. Mr.

81. Mr. Lovet, lay-clerk of the cathedral church at Worceſter †, ſays, that electricity is almoſt a ſpecific in all caſes of violent pains, of however long continuance, in any part of the body; as in obſtinate head-achs, the tooth-ach, ſciatica, and diſorders reſembling the gout.——As it would be unfair in me to tranſcribe too much of his Eſſay, I ſhall refer the reader to the work itſelf; which appears to be written with candour.

82. The Reverend Mr. Weſley has followed Mr. Lovet's method, and often quotes him.——He ſays he has ſcarce known an inſtance in which electrical ſhocks over all the body have failed to cure a quotidian or tertian ague *. He mentions a caſe of blindneſs cured by it, and even of its having given hearing to a man who was born deaf. He further ſays, it has cured bruiſes, running ſores,

† Lovet's Eſſay.
* Weſley's Deſideratum.

a palſy in the tongue, and has brought away gravel from the kidnies. In deep hyſterical caſes, he adviſes that the patients be ſimply electrified, ſitting on cakes of roſin, at leaſt half an hour morning and evening: then begin to take ſmall ſparks from them, and afterwards give them ſhocks, more or leſs ſtrong, as their caſes require; always beginning with gentle ſhocks.——This method ſeems very rational: and the Reverend Dr. PRIESTLEY very juſtly obſerves, that as electricity has done ſo much good in the hands of thoſe who are not phyſicians, and conſequently cannot be ſuppoſed always to diſtinguiſh between caſes where it might be advantageouſly applied, and where it might not; 'tis pity but that it were in the hands of able phyſicians *.

83. DR. ANTONIUS DE HAEN, in his Ratio Medendi (quoted by Dr. PRIEST-

* Prieſtley's Hiſtory of Electricity, p. 419. and 422.

LEY)

LEY †) one of the moſt eminent phyſicians of the preſent age, ſays, that a paralyſis and trembling of the limbs, from whatever cauſe it aroſe, never failed of being relieved by electricity; and he relates one inſtance of a particular caſe of this nature, where a perſon was cured after having received ten ſhocks. And he aſſures us, that it has never failed to cure the St. Vitus's dance; but it entirely failed in its application to a gutta ſerena, and to a ſtrumous neck.——He ſays, that it ought not to be adminiſtered to women with child: and Veratti adviſes, that it be by all means avoided in the venereal diſeaſe.

For my own part, being but a young electrician, I can have very little to ſay with reſpect to the medical part. But, as far as I have had experience, I ſhall here relate the facts.

† Ibid.

84. A woman, who complained much of a pain in her ſtomach, came to be electrified.——I gave her only one ſhock acroſs the ſtomach, and the pain immediately left her. But, on the next day, ſhe came and told me, I had driven the pain from her ſtomach into one of her teeth, ſo that ſhe was almoſt mad by the tooth-ach.——I then gave her a ſtrong ſhock through her tooth and gum (as deſcribed in the 19th experiment), on which the tooth-ach directly left her. I ſaw her about a week afterward, and ſhe told me that ſhe was quite well, and had no return of her late cauſe of complaint.——I have tried the like experiment on many others ſince, who were afflicted with the tooth-ach, and it failed only with three; in one of whom I obſerved the tooth was much ſpoiled and decayed.

85. A poor woman brought her daughter (who was about eight years of age) to be electrified for the rheu-

matiſm, which (as the woman ſaid) had ſettled upon the child's left knee, and ſo far taken away all the uſe of her left leg that ſhe had been quite lame for a month.——I drew ſeveral ſparks from the knee, which the child told me at firſt ſhe did not feel; but then ſhe began to feel them more and more acute.—— I deſired her mother to bring her on the next day, which accordingly ſhe did.——I drew ſparks from the knee for about a quarter of an hour, and from two or three inches both above and below it, till the ſkin became red and full of pimples; when the child told me ſhe felt it very warm, and could no longer endure the pain that the ſparks gave. I then ſent a gentle ſhock through her knee, after that a ſomewhat greater one, and laſtly a pretty ſtrong one, which made the child cry. I gave her twopence for her good courage, and ſhe told me I had now made her quite a gentlewoman, and that ſhe would never cry

out

out again when ſhe was brought to be electrified.——On the next day, the woman came alone, and told me ſhe had been very agreeably ſurpriſed; for her daughter came down ſtairs * to breakfaſt, without any help; but had got a ſad pain in her ſtomach, which muſt have been the rheumatiſm driven into it from her knee. I deſired her to bring the child directly; which ſhe did, and I ſent a tolerably ſtrong ſhock through the child's ſtomach; on which the pain ceaſed, and I heard nothing afterward of any return.

86. A man, whoſe left ſhoulder had been diſlocated by a fall from his horſe, and his arm very much bruiſed all from the ſhoulder to the elbow; came about a year after to be electrified.——He told me that a ſurgeon had replaced the bone very well, (as indeed it appeared to be;) but the

* The woman lodged in a garret, but dreſſed her victuals in the kitchen.

muſcles had been ſo much bruiſed, that he had never ſince been able to move his left hand a foot from his ſide, without the aſſiſtance of the right.——I told him, there was but very little reaſon to hope for any cure by electricity; however, I would try; and ſo gave him three ſhocks from the ſhoulder to the elbow, at the laſt of which, he held his arm out, almoſt half way into a horizontal poſition. I deſired him to come again the next day, which he did, and I gave him a couple of ſtrong ſhocks: then he held his arm directly right out; and without the aſſiſtance of his right hand, he unbuttoned and buttoned the collar of his ſhirt with the left. Whether the uſe of his arm continued or not, I cannot tell; for he went away, and I never ſaw him nor heard of him again.

87. A woman, who had a hard ſwelling in her left cheek, which ſhe told

me had come on in a very few days, came to be electrified.——I had hopes of succefs, as the complaint was of fo short standing. I first drew many sparks from the cheek, and then sent a couple of gentle shocks through it; desiring her to keep it warm afterward by covering it well with a double flannel cloth. She came again on the next day; I found the swelling was then much lefs, and soft. I drew off many sparks again, and gave three shocks, the last of which was pretty strong. She put on the flannel, went away, and returned the next day; when I found the swelling was so nearly gone, that I thought it needlefs to repeat the operation.

88. I was once, at Bristol, seized with a sore throat, so that I could not swallow any thing. Mr. Adlam, of that city, who is a fine electrician, came and drew many electric sparks from my throat, and in about half an hour after,

after, he did the ſame again. He ſtaid with me about an hour longer, and before he went away, I could both eat and drink without pain; and had no return of that diſorder. —— I have relieved ſeveral perſons in ſuch caſes, but never in ſo ſhort a time as Mr. Adlam cured me.

89. A young man, who had well-nigh loſt his hearing, ſo that thoſe who ſpoke to him were obliged to ſpeak very loud, came twice to be electrified. I only drew ſparks from his ears, and at the ſecond time he heard very well, and continued to do ſo afterward. —— But, ſince that time, I have tried the experiment on three perſons, without the leaſt ſucceſs; altho', after finding no good from the ſparks, I ſent gentle ſhocks through each ear alternately, to the oppoſite ſide of the throat.

90. In

90. In rheumatic cafes, I have generally found electricity fuccefsful; only by continuing to take fparks from the pained places, till the fkin has been red and pimpled, and the patient felt a glowing warmth where the fparks were drawn off. And I have found the fame method efficacious in old fprains.

91. I was once deceived by a man who had the venereal diftemper, (as I afterward found out) who came feveral times to be electrified, as he faid, for the rheumatifm; but, on finding him grow worfe and worfe, I fufpected the caufe, and queftioned him. He ftrongly denied the fact, even though I told him that if he had that complaint, electrifying would not only hurt him greatly, but might even kill him: and fo I fent him away, telling him that he needed not come any more. —— He then thought proper to apply to a furgeon, who cured him, and told

told me afterward what his real caſe was.

92. I have never tried electricity in paralytic caſes, nor in the gout. In the laſt of theſe, I never intend to try it, until I find that others have done it with ſucceſs.

93. The ingenious Mr. William Swift, a turner at Greenwich (who makes good electrical machines), has lately cured Mrs. Allmey, a baker's wife in that town, of a hemiplegia or dead palſy in one ſide, in which ſhe was ſo far gone, that boiling water might have been applied from her hand to her ſhoulder, and from her ſhoulder to her foot, on that ſide, without being felt by her. Dr. Green, who attended her, ordered Mr. Swift to electrify her, which he accordingly did, ſometimes drawing ſparks for a whole hour together, and ſometimes for two hours, all over where the palſy was; and then giving ſhocks.

Her

Her feeling is now quite reſtored, ſhe walks very well, and I ſaw her name, which was well wrote by the hand of which ſhe had quite loſt the uſe.——As this is a very remarkable caſe, I ſhall ſet down the different times of electrify-ing, and the number of ſhocks given each time, from the account ſent me by Mr. Swift, with whom I am very well acquainted. He firſt gave ſtrong ſhocks till ſhe began to feel them, and then moderate ones.

Times of electrifying.		Shocks.
Sept. 3, 1769, for	1 hour	4
5	1	6
7	2 hours	12
8	2	12
9	1½ hour	12
11	2 hours	9
12	2	12
13	2	12
16	2	9
19	1½ hour	6
23	1½	8
24	2 hours	7
Oct. 3	1½ hour	6
4	1½	6
6	2 hours	5
9	2	7
16	2	4
18	2	4
In all, 18 times.	31½ hrs.	141 ſhocks.

94. I lately (by defire) tried electricity for a lady who had a ftiffnefs in the principal mufcle on one fide of her neck, and a fmall hard fwelling thereon, not fo big as a hazel-nut. Her head was turned toward one fide, and fhe could not without pain turn it toward the other. I continued to draw fparks from her neck, a quarter of an hour each day, for a week: but fhe did not receive the leaft benefit thereby.

95. I have often drawn fparks from chilblains, and always found they were cured thereby.

96. One time my wife happened to fcald her wrift by boiling water. I fet her upon the glafs-footed ftool directly, and took fparks from the wrift. In a fhort time I found the rednefs of the fkin (occafioned by the fcald) begin to difappear, and fhe felt immediate relief. A linen bandage was then put round

her wriſt, and in a few hours after, I repeated the operation, which entirely cured her, and there was not the leaſt bliſter on the ſkin, nor any difference in its colour from what it had before the accident. If it had not been taken immediately, and before a bliſter had riſen, perhaps electrifying would have been of little or no ſervice.

97. In caſes where ſhocks are given, I ſhould always think it adviſable to begin with gentle ones; and, if the diſorder will not yield to theſe, increaſe them gradually.——The ſhocks may be made as ſmall as the operator pleaſes; for, if he charges the jar but a very little, they will be little accordingly.

F I N I S.

The Binder is desired to put the Plates at the End.

A

CATALOGUE

OF THE

APPARATUS

On which Mr. FERGUSON *reads his Courſe of twelve Lectures, on Mechanics, Hydroſtatics, Hydraulics, Pneumatics, Electricity, and Aſtronomy.*

[The Numbers relate to the Lectures read on the Machinery to which they are prefixed.]

I.

SIMPLE machines for demonſtrating the powers of the lever, the wheel and axle, the pullies, the inclined plane, the wedge, and the ſcrew.

A compound engine, in which all theſe ſimple machines work together.

A work-

A working model of the great crane at *Briſtol*, which is reckoned to be the beſt crane in Europe.

A working model of a different crane that has powers adapted for raiſing different weights; invented by Mr. *Ferguſon*.

A pyrometer, that makes the expanſion of metals by heat viſible to the ninety thouſandth part of an inch, ſo as to be ſeen by the bare eye at two feet diſtance from the machine.

II.

Simple machines for ſhewing the center of gravity of bodies, and how far a tower may incline without falling.

A double cone, that ſeems to roll up-hill of itſelf while it is actually deſcending.

A machine made in the figure of a human creature, that tumbles backward by continually overſetting the center of gravity.

Models of wheel-carriages, ſome with broad wheels, others with narrow; ſome with large wheels and others with ſmall; for proving ex-

perimentally

perimentally which ſort is beſt, and what is the beſt way of loading waggons.

A machine for ſhewing what degree of power is ſufficient to draw a cart or waggon up-hill, when the quantity of weight to be drawn up, and the angle of the hill's height, are known.

A machine for diminiſhing friction; and ſhewing that friction depends not on the quantity of ſurface that rubs or rolls, but on the weight of the machine and its load.

A model of a curious ſilk-reel, invented by Mr. *Verrier* near *Wrington* in Somerſetſhire.

A large working model of a water-mill for ſawing timber.

A model of a hand-mill for grinding corn.

A model of a water-mill for winnowing and grinding corn, drawing up the ſacks, and boulting the flour.

A model of the engine by which the piles were driven for a foundation to the piers of *Weſtminſter*-bridge.

A ma-

A machine for demonſtrating that the power of the wind, on windmill ſails, is as the ſquare of the velocity of the wind.

III.

Machines for ſhewing that fluids weigh as much in their own elements as they do in air: ——that fluids preſs equally in all manner of directions:——that their preſſures are in proportion to their perpendicular heights, without any reſpect to their quantities:——that on equal bottoms, their preſſures are as their perpendicular heights, be their quantities ever ſo great or ever ſo ſmall:——that an ounce of water in a ſmall glaſs-tube will raiſe and ſupport ſixteen pound weight, or any other aſſigned quantity of weight:——that ſolid lead may be made to ſwim in water, and light wood to ſink therein:——for demonſtrating the hydroſtatical paradox:——for proving that the quantity of water diſplaced by a ſhip is equal to the whole weight of the ſhip and cargo:—— the working of ſyphons:——the *Tantalus*'s cup:——the cauſe and phenomena of ebbing and flowing wells, and of intermitting and reciprocating ſprings.

IV.

Machines for ſhewing that when ſolid bodies are immerſed and ſuſpended in fluids, the ſolid loſes as much of its weight as its bulk of the fluid weighs; and that the weight loſt by the ſolid is imparted to the fluid.

A hydroſtatic balance, for ſhewing the ſpecific gravities of bodies, and detecting counterfeit gold.

A working model of ARCHIMEDES's ſpiral pump.

Working models of ſucking, lifting, and forcing pumps.

A working model of a quadruple pump-mill, for raiſing water by means of water turning a wheel.

A working model of the *Hungarian* engine for raiſing water from mines.

A working model of Mr. *Blakey*'s fire engine.

A working model of the Perſian wheel for raiſing water.

A model

A model of the great engine at *London*-bridge for raiſing water to ſupply the city.

V. and VI.

An air-pump, with a very large apparatus, for experiments ſhewing the weight and ſpring of the air.

VII.

An electrical machine, with ſuch an apparatus to it as is deſcribed in this treatiſe.

VIII.

A whirling table, for explaining and demonſtrating the laws by which the planets move, and are retained in their orbits: that the ſun and all the planets move round the common center of gravity of the SOLAR SYSTEM: that the earth and moon go round the center of gravity between them, once every month: that the earth goes round the ſun, in common with the reſt of the planets, and turns round its own axis: that the power of gravity diminiſhes in proportion as the ſquare of the diſtance from the attracting body increaſes: that a double velocity in any orbit, would require a

quadruple

quadruple power of gravity to retain the body in that orbit: that the ſquares of the times in which all the planets go round the ſun are in proportion to the cubes of the diſtances from the ſun. A plain experimental demonſtration of the doctrine of the tides; and the cauſe of their riſing equally high, at the ſame time, on oppoſite ſides of the earth.

IX, X, XI, and XII.

A machine for ſhewing the motions of the comets.

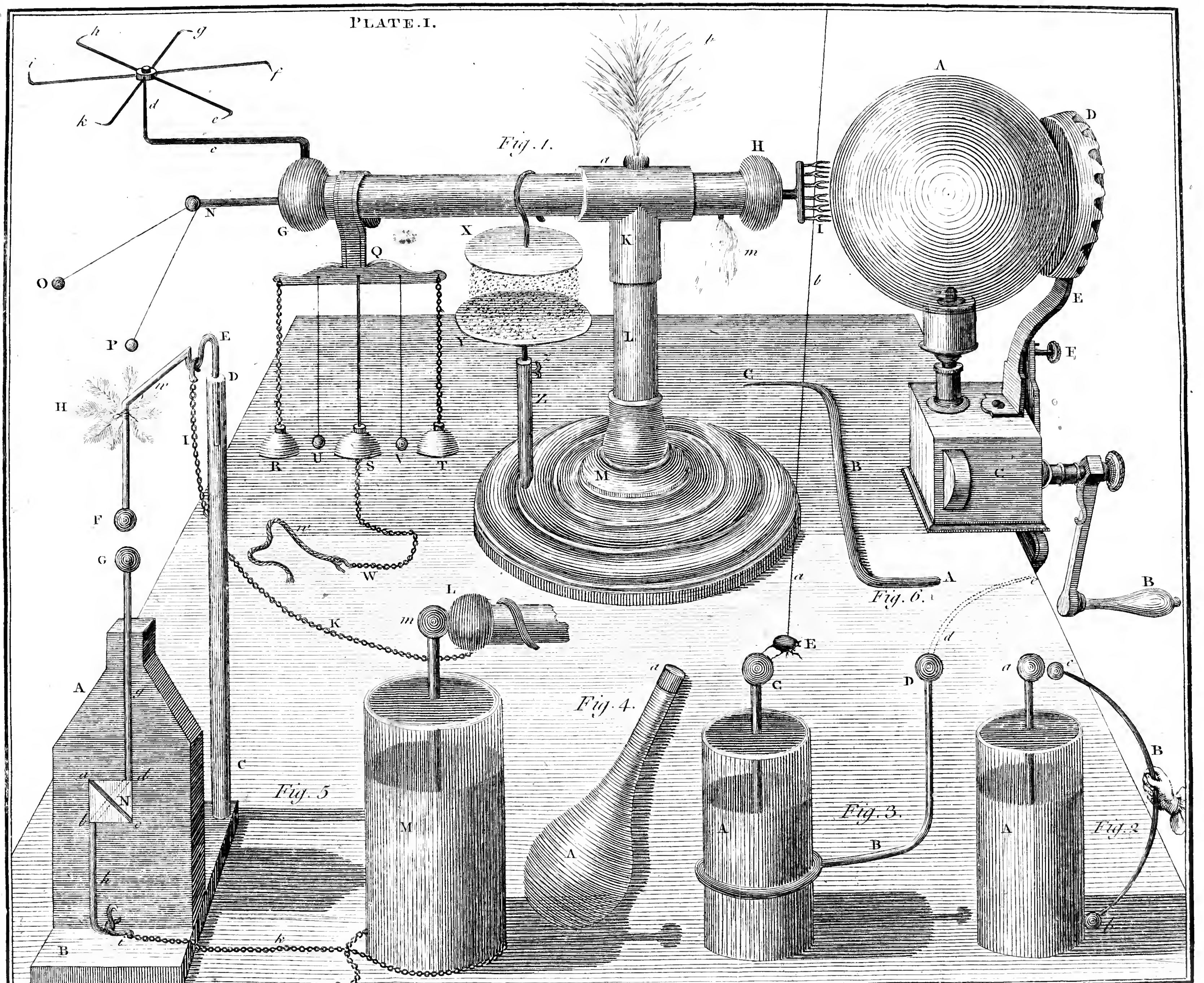
An Orrery, ſhewing the diurnal and annual motions of the Planets; the apparent ſtations, direct and retrograde motions of Mercury and Venus, as ſeen from the earth: the different lengths of days and nights, and all the viciſſitudes of ſeaſons, ariſing from the earth's diurnal and annual motions: the motions and various phaſes of the moon: the harveſt moon: the tides: the cauſes, times, returns, and phenomena, of all the eclipſes of the ſun and moon: the eclipſes of Jupiter's ſatellites, and phenomena of Saturn's ring, &c.

In London, any number of perſons, not leſs than thirty, who will ſubſcribe one guinea each, may have a courſe of twelve lectures read on the above-mentioned apparatus, provided they agree to have at leaſt three lectures a week: in which they may appoint the days and hours that are moſt convenient for themſelves: *Sundays* excepted.

Within ten miles of London, any number of perſons, not leſs than forty, may have a courſe; each ſubſcriber paying a guinea, and agreeing to have ſix lectures a week. And

Within an hundred miles of London, any number of ſubſcribers, not leſs than eighty, may have a courſe, each paying as above, and agreeing to have ſix lectures a week.—Greater diſtances require a greater number of ſubſcribers.

PLATE. I.



I. Ferguson delin.   I. Bayly sculp.

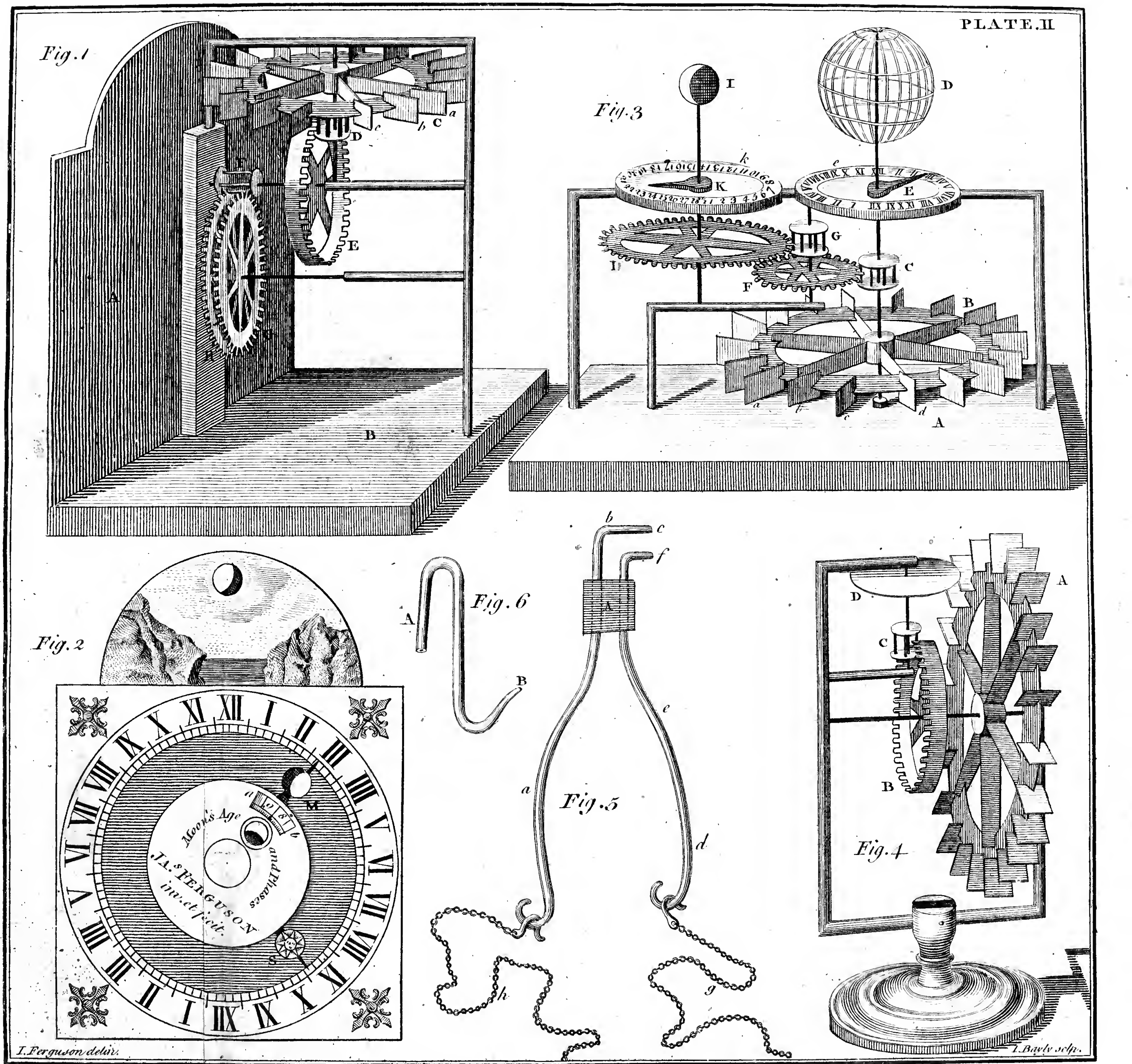
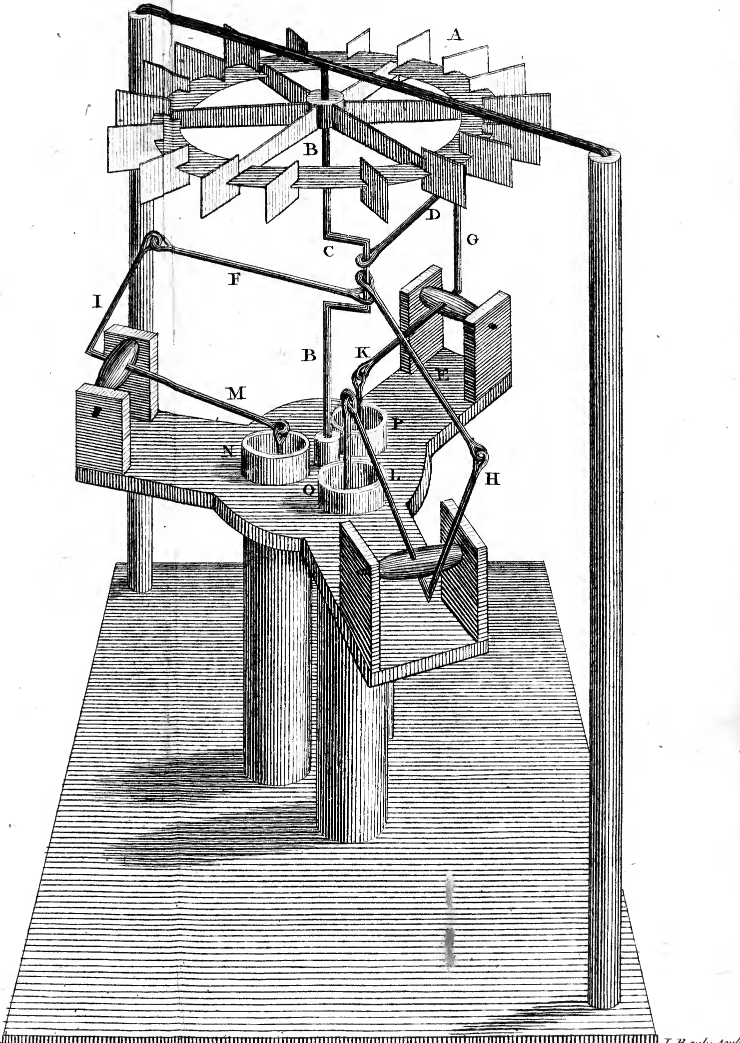


PLATE.II
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Moon's Age and Phases
JA.S FERGUSON inv. et fecit.
I. Ferguson delin.
I. Bayly sculp.

PLATE. III



I. Ferguson delin. I. Bayly sculp.